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Growing Tree and Small Fruits

SELECTED AND PREPARED BY THE EDITORIAL STAFF
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Growing Tree and Small Fruits

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United States Department of Agriculture

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PREFACE

This book is intended to meet the needs of schools and departments of vocational agriculture. Since these agencies are concerned primarily with the practical phases of fruit growing, it follows that this book, if it achieves its purpose, should also be useful to those who are actually engaged in growing fruit.

The activities are arranged on the seasonal basis, beginning with the harvesting of the crop, since this is the job that faces the grower at the time students take up their work in the fall. Each enterprise is broken down into its various operations just about as such operations would present themselves for consideration in practice. The community studies at the end of the chapters should tie the instruction into the practices of the local area.

It is not necessary to begin at the front of the book and follow it page by page to the final chapter. In some sections of the country the culture of grapes, the harvesting of peaches, or the installation of a stationary spray plant may not be matters of commercial significance. The parts of the book dealing with such subjects are complete in themselves and may be omitted outright without detriment to the subjects that are of importance in any state or section.

It has not seemed worth while to include a detailed treatment of the life histories of the various insects and diseases of fruit. Such a treatment would require a book in itself. The student has been referred to his local experimental station and college of agriculture for information concerning the insects and diseases of importance in his community. Emphasis in this book has been placed rather on the mechanics of the use and application of materials for control, including a full discussion of machinery.

Likewise, information concerning varieties and variety descriptions is available from so many authoritative sources that it has not been included here, other than to enumerate the varieties of commercial importance in the various fruit-growing sections.

The Authors and Editors

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GROWING TREE AND SMALL FRUITS

PART I. TREE FRUITS

CHAPTER I

HARVESTING, STORING, AND MARKETING

The grower lays the foundation for a satisfactory harvest when he prunes, sprays, thins his fruit, and manages the soil properly. No attention given at the harvest season itself can make up for neglect of these essential factors of orchard management.

One of the best things the fruit grower can do at the outset is to take membership in organizations which seek to promote the industry by which he makes his living. Among these would be his state horticultural society by whatever name called, the sectional or local horticultural organizations, and the county farm bureau. Study the reports from these organizations, give careful consideration to their suggestions, and attend their meetings whenever possible. Keep informed through the United States Department of Agriculture and other sources regarding crop prospects and yields, cold-storage holdings, shipments, etc. Such action constitutes the best investment the grower can make and offers the highest insurance at the cheapest rate that he can have on his business.

I. THE APPLE

In planning for the harvest and all the activities that relate to the handling of the crop, the grower must give consideration to the following major factors.

Operations:

1. Picking.
2. Packing.
3. Determining harvesting marketing costs.
4. Storing.
5. Marketing.

In some seasons and in some sections the grower may not himself assume responsibility for all these factors. Before he can decide whether or at what stage he should turn the matter over to others, he must know what is involved in carrying through the complete program himself.

1. Picking. Once the fruit is ready to pick there is no time for matters that should have received attention earlier. The product is perishable. It must not remain too long on the trees for it will spoil or freeze. It must not drop to the ground for it will bruise. The time when it is at its best for handling is short.

Procedure:

(*a*) Estimating the yield.
(*b*) Providing adequate equipment.
(*c*) Securing an adequate supply of labor.
(*d*) Determining the proper time for picking.
(*e*) Picking the crop.

(*a*) *Estimating the Yield.* Many growers and buyers attain great proficiency in estimating yields while the fruit is still on the trees. This faculty comes only as a result of practice based on careful study of the trees and a knowledge of the bearing habits of varieties. For instance, a Tompkins King tree seldom measures up in performance to its apparent promise. It "shows up," for all and more than it is worth. On the other hand, McIntosh and York Imperial, which bear all through the top, will habitually do better than they promise.

Yields per tree or per acre vary with many factors. Among these are age and variety, number of trees per acre, methods of management, and the region itself.

Most published figures on production are of limited value to the individual orchardist because they are usually based on all orchards in a certain section. Among these are often orchards receiving poor care, those just coming into bearing, and those well past their prime.

A yield of 200 to 250 bushels per acre of packed fruit is probably an average figure for good commercial orchards in full bearing in New York, the oldest fruit section in the country. To this must be added a proportion of the crop, varying with the season and the care, which may be merchantable in the form of by-products, but which does not justify incurring package and packing costs for it. The good grower in every region constantly seeks to reduce this proportion of low-grade fruit and to increase the quantity of quality stock.

The average yield in commercial orchards of the Middle West is perhaps 175 bushels per acre, the yields showing considerable variation from year to year in some sections, as Missouri. Yields in Ohio, Michigan, and adjacent territory, as well as in the New England fruit sections, are similar to those of New York. Yields in the Atlantic Coast States, especially those of the Shenandoah-Cumberland section, in full crop years compare favorably with those of New York, but yields are more variable, largely owing to frost damage in the spring when the trees are in bloom.

In the Pacific Northwest yields per acre run higher with a lower percentage of cull stock than in other orchard sections. This is due in part to younger trees, a larger number of trees per acre, and more intensive methods of management. The Wenatchee Valley of Washington has been producing from 500 to 600 boxes of 40-45 pounds per acre as an average from orchards in commercial bearing. The Yakima Valley in the same state has produced from 400 to 500 boxes and the Hood River Valley of Oregon 250 to 400 boxes per acre. The trees in these sections have commonly been set about 20 by 20 feet, accounting in part for the higher yields. In many orchards part of the trees are now being removed to give more distance between trees. This will probably reduce the yield per acre for a few years at least. Although trees come into bearing younger in the Pacific Northwest than in the Eastern States, it is probable that their productive life is considerably less.

Table 1 gives the average annual total and commercial production of apples in the United States for the 1927-36 period and separately for 1937 and 1938. This table brings out the marked variations in given years from the long-term average. Over a long period of time total production is declining while commercial production is being maintained. This is probably due to better orchard management and the gradual concentration of the apple industry in the more-favored fruit regions.

TABLE 1

PRODUCTION OF APPLES IN THE UNITED STATES

	Average 1927-36	1937	1938
Total, bushels	150,728,000	210,783,000	131,882,000
Commercial,* bushels	92,821,000	115,733,000	82,395,000

*The part of the total crop sold for consumption in the fresh or original state.

The leading commercial states in order of their importance are listed in Table 2. Note that there are wide fluctuations from year to year from the long-term average. These fluctuations are less marked in the Pacific Coast States than elsewhere. Figure 1 also emphasizes this point.

The grower should study his orchards after the crop has set, after the "June drop," and at least once more a month before harvest. He should estimate the probable yield by inspecting at least 5 trees per acre carefully, taking pains not to be misled by heavier crops on outside rows or on unimportant varieties, or by a few trees carrying abnormal loads. If he

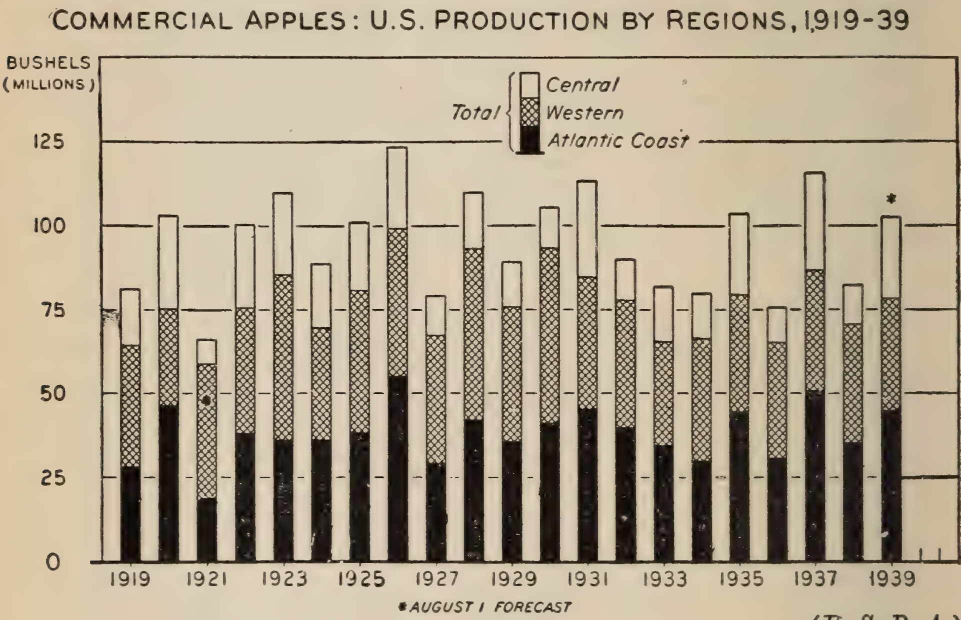
TABLE 2

COMMERCIAL PRODUCTION OF APPLES BY STATES

State	1927-36 Average	1937	1938	1939
	1000 bu.	*1000 bu.*	*1000 bu.*	*1000 bu.*
Washington	24,892	22,450	21,300	19,500
New York	11,444	12,863	9,800	14,500
Virginia	7,609	10,391	6,800	7,500
California	4,945	5,529	4,202	4,354
Michigan	4,869	8,500	4,800	7,800
Idaho	3,759	3,100	2,500	2,150
Pennsylvania	3,742	6,500	3,800	6,100
West Virginia	3,410	5,500	3,150	4,000
Ohio	2,964	6,000	1,950	5,800
Oregon	2,905	2,154	2,500	2,000
Illinois	2,823	5,900	1,950	4,700
New Jersey	2,336	3,600	2,750	2,950
Massachusetts	2,081	2,598	1,413	2,420
Colorado	1,744	1,116	1,700	1,100
Maryland	1,266	1,750	1,350	1,700
Delaware	1,146	2,144	1,450	1,750
Missouri	1,137	2,200	200	1,400
Connecticut	957	1,500	946	1,030
Maine	953	769	523	900
Arkansas	845	1,288	200	625
Indiana	812	1,700	633	1,250
Kansas	725	978	500	770

will check these estimates against the final yield, doing this year after year, correcting his figures according to the lessons of the past, he will eventually be able to make estimates that will be of very great value to him.

(*b*) *Providing Adequate Equipment.* The first thing to do is to inventory the equipment on hand that is in usable condition. Each picker should have a ladder which he can use where needed and for which he is responsible. The ladder should be light, strong, and well balanced. A flaring base increases its stability. A ladder which is wide at the bottom and tapers gradually to a point at the top is popular in many sections. It can be shoved between the branches and into small openings without disturbing the fruit and is raised easily by one man. In other sections the open top pattern



(U. S. D. A.)

FIG. 1. About 60 percent of the total apple crop is commercial apples, and the commercial crop is only slightly lower than it was 10 years ago. Of the commercial crop, the Atlantic Coast States produce about 45 percent, the Western States about 35 per cent, and the Central States about 20 percent. Commercial production fluctuates less in the Western States than in the Central and Atlantic Coast States.

is preferred. Either type may be desirable or undesirable, depending upon the man who handles it.

Ladders of uniform type and length are best in orchards of a given age. Many growers have adopted a 22-foot ladder for bearing orchards; ladders of greater length are difficult for one man to handle. Use as short a ladder as possible, keeping in mind that pickers cannot work on a ladder in a position too nearly vertical and that frequent reaching above the head because the ladder is too short reduces the quantity of fruit picked.

The tops of many trees in some of the older sections cannot be picked with anything shorter than a 28- or 30-foot ladder. If such trees have a place in the commercial orchards of the future, a well-balanced extension ladder will meet the need. Step ladders are also useful for small trees and those with bearing surfaces near the ground. A single leg or prop in front prevents tipping. See Fig. 3.

Fig. 2. Careful inspection of the trees is essential to a dependable crop estimate.

In selecting receptacles for picking, safety of fruit from injury is the first consideration. The second is ease and rapidity of manipulation. Oak-stave baskets, half-bushel or three-quarter-bushel size, with drop handles and padded inside have been popular in many sections. However, the picker spends so much time in moving them about, even though the handles are equipped with hooks, and it is so easy to dump the basket by catching it on a branch, perhaps losing all the fruit in it, that this type of receptacle is losing favor.

Large pails are preferred by many orchardists. They may be attached to a strap over the shoulders. They are especially desirable for tender varieties. The sound of careless pickers dropping the apples into them may be readily heard. Picking bags with bottoms that open may answer for harder varieties and in the hands of careful pickers. The bag enables the picker to use both hands in picking but he is liable to bruise the fruit by knocking the bag against the rungs of the ladder.

A metal picking bucket, with a canvas drop bottom, suspended from the shoulders of the picker is now used almost exclusively on the Pacific Coast and is gaining favor in Eastern sections (Figs. 4 and 5). The sides have sufficient rigidity to protect the fruit, and the receptacle is easily carried and emptied.

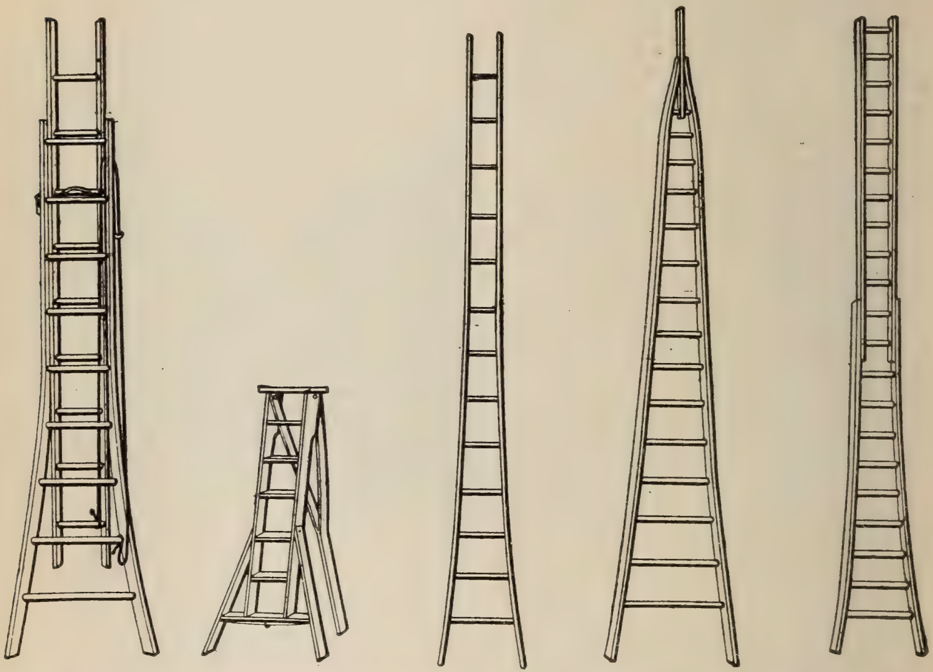


Fig. 3. Types of orchard ladders. The extension ladder at the left is too cumbersome. The three ladders at the right, in varying lengths depending on the height of the trees, are most desirable. A distinct flare at the base increases stability.

If the trees are low and the crop is heavy, a 16-quart peach basket makes a very good picking container. It can be attached to the picker either by a heavy adjustable canvas strap with hooks on each end of it or by fastening the ends to a wire ring that will fit under the hoop on the basket.

Any receptacle may be satisfactory when used by a careful workman; any may be objectionable, if carelessly used.

Receptacles into which the fruit may be emptied by the pickers must be provided. Slat crates are convenient to handle and stack, but the sharp edges may dent and injure the fruit unless the slats are close enough together to prevent this. Lug boxes of solid but unfinished lumber, with slots in each end for the hands and holding about a bushel, make good packages.

Fig. 4. This metal picking bucket, with padded top and canvas drop bottom holding ½ bushel, is popular both in the East and West. It protects the fruit and permits the picker to use both hands. Some growers prefer a larger receptacle, especially for picking trees with high heads.

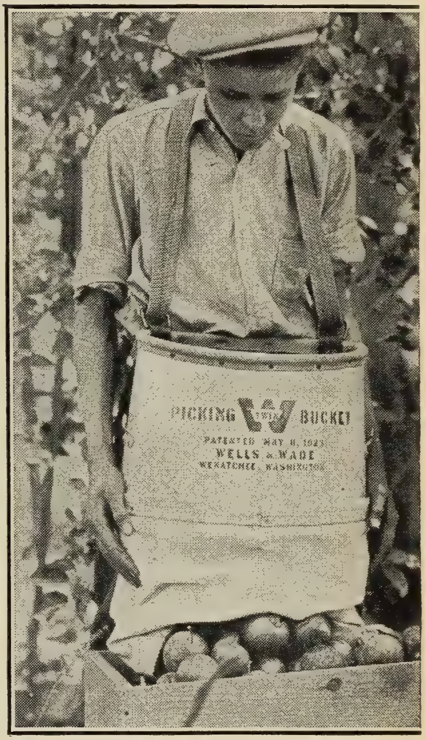


Fig. 5. The same as Fig. 4 opened to empty the fruit. The bucket may be carried under one arm with the strap over the shoulder, if desired.

By nailing strips on the top of each end, they may be stacked without injury to the fruit.

Trucks, trailers, or wagons should be low to eliminate as much lifting as possible. They should be equipped with good springs and rubber tires so that the fruit will be carried as carefully as possible. To be able to maneuver between the trees the trucks must turn in a small place. Many fruit growers make their orchard trucks from heavy second-hand cars. Others use equipment which is specially designed by a manufacturer of farm machinery. Wide racks to hold the packages should be provided.

Containers in which to pack the fruit are treated later. The grower will naturally, however, inventory his supply on hand and order his requirements, including graders or other machinery, for the coming season, when he is arranging for the equipment for his picking operations. A considerable saving may usually be made by ordering early in the season.

(*c*) *Securing an Adequate Supply of Labor.* In established orchard regions, practically all workers have had experience in harvesting the crop. In addition to the labor which is resident in the section throughout the year, hundreds of roving workers, both men and women, may come in for the picking season. Frequently they return year after year and form a valuable source of supply. The grower should have a nucleus of responsible resident workers on whom he can rely. He may complete his picking gang from this floating help.

In determining the amount of help needed, the grower must be governed by the normal picking dates of his varieties, the crop of each variety in a given year, and the amount of time at his disposal to complete the picking operation. Such factors as the location of the orchard, on steep or level land, and the height of the trees will also enter in.

Picking is done by the day or by the piece. Picking by the bushel will take more fruit from the trees in a given length of time, but often it results in careless handling and serious injury to the apples. Where the quantity to be picked is not great, day labor well supervised will give better results; where large quantities must be handled, the contract system, even more carefully supervised, is preferable. The quantity picked in a day will vary with many factors, as height of trees, how full trees are, size of fruit, the ease with which it separates from the spurs, etc. Under the piecework plan in the older fruit sections with large and high trees, 50 to 60 bushels per day is a good average for an experienced picker who does his work well.

In the younger orchards where trees with low heads and a broad bearing surface in proportion to their height have been developed, 75 to 100 bushels per day will be picked by piecework under normal conditions.

Day work will yield on the average from two-thirds to three-fourths as much fruit as piecework.

(*d*) *Determining the Proper Time for Picking.* The time for picking must be determined both by economic and natural factors. If the crop is large, the grower cannot wait until all the fruit is in the best natural condition. He must begin his harvest soon enough so that he may complete it before the fruit is too long past the most favorable condition. If he has varieties that mature a few weeks or even days apart, it will help considerably in organizing his picking operations.

Consult the information on page 177 for the number of days certain varieties require to mature as determined by the United States Department of Agriculture. Always keep a record of the date of full bloom of your varieties, and note the variation in these dates from year to year.

Early or summer varieties which are moved to market at once should usually be picked as soon as they reach merchantable size and color and while prices are good. Later increases in size and color usually are not sufficient to offset the rapidly falling market.

If the fruit is to be held in storage for an indefinite time after picking, the proper stage for picking becomes of very great importance. This is especially true of varieties subject to storage scald. The firmness of the flesh of the apple, the amount of yellowing or the change in ground color in the unblushed portions, and the ease with which the fruit separates from the spurs are among the most important evidences of proper maturity.

The degree of yellowing in the uncolored portion of the fruit away from the sun is of considerable significance as an indication of proper maturity. Standard color charts are available from the United States Department of Agriculture.

The development of red color is a factor of great economic importance. Red varieties should be left on the tree as long as is possible with safety so that they may attain the highest possible color. The dark or leaf green of the ground color should be replaced by a decidedly lighter shade. Apples picked while dead green, as has often been done with Rhode Island Greening, are likely to "scald," or turn brown in storage.

Apples ripening in warm weather must be picked promptly since they will deteriorate rapidly; those ripening in the late fall may be picked over a longer period. The grower should keep in mind that fruit ripens more slowly on the tree under normal conditions than after picking or when held in common storage. In other words the best place to keep apples, unless they can go immediately into cold storage, is often on the tree.

The brown color of the seeds is another indication of approaching maturity but it is by no means conclusive evidence. Apples grown in sod will mature more quickly than those grown under cultivation. Those grown in sandy soils will mature sooner than those grown in heavy soils. Fruit on the north side of a tree colors more slowly than that on the south or east sides.

As a general rule, pick the apples when most of them separate easily from the fruit spurs, and before they begin to drop freely. They will in most cases still be hard and firm.

With some varieties, as McIntosh, it may be necessary to make two or even more pickings in order to save the marketable fruit, as some of the apples will color and drop before the others are ready. Likewise trees of Wealthy may need several pickings in order that all the crop may be of good size and color. Going over the trees more than once, or "spot picking," is becoming general practice in many fruit sections. It is especially desirable in sections growing and packing high-quality fruit. It is usually justifiable on the basis both of sufficient increase in value of the product, and of taking advantage of the high prices often prevailing early in the season.

Some varieties naturally "hang" better than others. The good grower knows this and takes advantage of the fact in his picking plans. In general, a variety with a long stem may be left longer than a variety with a short, clublike stem.

In recent years, to avoid repeated pickings and obtain the best possible color, experiments have been conducted to see to what extent apples change color after they have been picked. With some varieties a much improved color may be obtained on the green apples left on a mulch under the tree for a few days. This is especially true of McIntosh. Such fruit, when placed in storage, does not remain as firm as fruit freshly stored. If it is watched carefully, however, it may be placed on the market as of a higher grade than if it lacked the added color. The fruit should not be placed in direct sunlight, but in partial shade. Developments in this field should be watched carefully during the next few years, especially in sections close to market.

A New Consideration. Efforts are now being made to control the pre-harvest drop of apples by spraying the fruit with certain plant hormones or growth substances. Rather remarkable results have been achieved to date, and the investigations are being continued. Work in this field has thus far been done by the United States Department of Agriculture at its horticultural station at Beltsville, Maryland, and in cooperation with the Department of Pomology of Cornell University in western New York.

The matter is of great importance to the grower, since any economical procedure which will both hold the fruit longer on the trees and increase its color works greatly to his advantage. The yield of hand-picked fruit will be correspondingly increased, the higher color adds to the value of every bushel, and the lengthened period of harvest helps the grower with his labor problem. Some varieties, noticeably McIntosh, drop freely and almost unpredictably. It so happens that McIntosh is one of the varieties most influenced by the treatment. However, all the twenty odd varieties thus far used in the experiments have responded to a marked degree.

The treatment delays the formation of the abscission layer between the stem and the spur, and because of this delay the fruit does not drop. Among the many synthetic growth substances used, naphthaleneacetic acid and naphthaleneacetanide have been most effective with little to choose between them. Quantities used are exceedingly small, a concentration of 0.0005 percent or 5 parts per million being effective. This is about a half teaspoonful to 100 gallons of water. The materials to date have been dissolved in small quantities of ethyl or methyl alcohol (merely to hasten solution) and added directly to water in the spray tank. The use of spreaders has also seemed desirable. Combinations with the usual orchard sprays have not been attempted because this is a harvest or pre-harvest application.

The coverage of the fruit must be thorough. This may require from 5–8 gallons on small bearing trees to as much as 20 gallons on large trees carrying heavy crops. The effect of the application on most varieties is marked for 2 to 3 weeks. With McIntosh, however, with materials used to date the effect diminishes sharply after 8 or 9 days. It is probable, therefore, that the application should be made on McIntosh just as dropping begins. A second spray may be applied as the effect of the first wears off if the quantity of fruit to be harvested and the cost make it advisable.

McIntosh trees receiving the one treatment have yielded nearly 14 bushels of picked fruit against 8 bushels from check trees. At the end of 8 days after the treatment the percentage of drop has been 6.8 percent against 35.9 percent on check trees. To date no undesirable after-effects on fruit or tree have been noted.

Costs at present are rather high (in 1939, four or five cents per gallon of spray). It is expected, however, that, with a large potential market, chemical companies will be able greatly to reduce these costs and bring them well within the range of economical procedure for the grower. Substantial improvements in convenience of handling, probably making the materials available in units to be added to the spray tank, are also expected.

It should be kept in mind that these are preliminary findings. Future developments should be watched with the greatest care. The matter is one of great possibilities and implications. The grower should keep in touch with the United States Department of Agriculture, the experimental stations and colleges, and the usual public service agencies.

(*e*) *Picking the Crop.* Begin with the lower branches and work upward in order to reduce dropping of fruit to a minimum. The stems should not be twisted or torn out, because appearance and keeping qualities are injured. The spurs should not be damaged, because on them depends subsequent crops. The fruit must not be cut with the finger nails or dropped into the receptacle. It is a ruinous and shortsighted policy to bring fruit to maturity in a high degree of perfection and then to depreciate its value in the picking and packing processes.

Remove the fruit with an upward motion and twist of the wrist. Harvest it only when dry, if possible, since wet fruit has a soiled appearance, and, if it goes into a closed packing at once, provides favorable conditions for development of scab, mold, etc.

As a rule, put only one or at most two men on a tree, both because of greater efficiency in the picking process, and because their work may be carefully checked.

A convenient way for one man to raise a ladder is to thrust one leg or side of the ladder into the ground or against a firm support and to elevate it sidewise, exerting some pressure downward at the same time to keep the base from slipping. In carrying the ladder allow it to tip back over the head slightly out of the vertical, grasping a rung near the base with one hand and another rung with a hand extended above the head.

Place the ladder when possible in such a position that if dislodged it will fall toward the center of the tree, so that its fall will be arrested before it has gone far. Most accidents come from failure to observe this precaution.

The pickers should be relieved of the fruit near the trees they are picking so that they give all their time to the picking operation. Other workers may empty the fruit carefully into crates or lug boxes to be hauled to some central point or packing shed, or if the fruit is packed in the orchard, they may take it directly to the packing tables. There should be an adequate supply of picking receptacles so that the pickers do not have to wait for them.

The rate of picking has been indicated in connection with securing an adequate supply of labor. The grower may well give considerable thought to the details of organization of his picking crew, in order that the job may be well done, with the greatest possible efficiency under the conditions. With cold weather approaching, with heavy winds in prospect and the fruit ready to come off, every hour is precious.

2. Packing. Whether or not the grower packs his own fruit will depend upon the method of sale of his crop as presented under "Marketing." In any case, the fruit should either be packed at once after picking, or put in storage where deterioration will be arrested until the packing is done. Some growers who have their own cold-storage plants put the fruit as it comes from the trees directly into storage and pack it out at their convenience and as they wish to market it, after the picking season is over. As a rule, however, storage costs should not be incurred on fruit which will be discarded in the packing operation and by far the larger proportion of the commercial crop is packed immediately after picking.

Procedure:

(*a*) Determining type of package to use.
(*b*) Determining grades and sizes to be made.
(*c*) Determining where packing is to be done.

(*d*) Grading the fruit.
(*e*) Packing in barrels.
(*f*) Packing in Western boxes.
(*g*) Packing in Eastern boxes.
(*h*) Packing in baskets.
(*i*) Removing spray residues.

(*a*) *Determining Type of Package to Use.* Apples go to market in many containers. Each has its uses and particular adaptations.

In making his decision as to the type of package to use the grower should take into account the following factors:

(1) Varieties.
(2) Quality of the crop.
(3) Market preferences and tendencies.
(4) Size of commercial crop.
(5) Size of individual crop.
(6) Where crop is marketed.
(7) Specifications of packages.

(1) *Varieties.* Quality apples should go into a package that means quality to the buyer and consumer. It is equally true that quality packages should not be used for mediocre fruit. Quality in fruit is a term which to the consumer means external attractiveness and finish, as much as or more than flavor.

Some varieties are extremely tender. McIntosh is an example. Varieties that are commonly regarded as dessert or eating apples should as a rule be packed in containers that insure as far as possible freedom from bruising and perfect condition.

Varieties of medium quality purchased for cooking and general uses, as Baldwin or York Imperial, may well be packed in the larger containers.

(2) *Quality of the Crop.* Owing to the season or to better management on the part of the grower, the quality of the crop may be much higher one year than another. This may justify a change in the type of package used. The appearance and

finish of the crop may raise it not only to a higher grade but perhaps to a package representing higher standards. The grower should not be misled, however, by the presence of a minor quantity of highly colored and attractive specimens in the crop. To pack these into the higher grades may so reduce the appearance of the remainder of the crop as to make the project uneconomical. The attempt to pack the whole crop in a higher grade than the bulk of the crop justifies may have the same result.

(3) *Market Preferences and Tendencies.* The grower is concerned not merely with the disposition of his crop for a single year. The general trend of the market in its preferences is of great importance to him.

Market standards and requirements are gradually on the upgrade. Products, packages, and methods of packing acceptable to one generation may not satisfy generations that follow.

A few years ago the barrel was a very common package for domestic use. Now it is limited almost entirely to export trade. The barrel is a larger package than the fruit trade or the ultimate consumer of the present generation desires. It is not a good display package. Careless methods of packing and its use for mediocre fruit, much of which should not have been put in closed packages, have destroyed confidence in it.

Boxes of one style or another and holding approximately one bushel are the favored commercial packages of the day. They vary as to design and type and method of packing according to section and use as indicated under (7) *Specifications of Packages.*

Bushel baskets are still used but are losing favor. They are difficult to stack and store and are not rigid enough to give the fruit as much protection as is desirable.

Many small containers of family size for roadside stands and direct to the consumer trade have been developed.

The important thing is to determine which package the particular trade to be served desires.

(4) *Size of Commercial Crop.* When the commercial crop of the country is short, the proportion of the crop to be put in closed packages may usually be increased to advantage. When the crop is average or above, the standards must be raised correspondingly, only the better fruit being likely to pay the attendant costs.

This does not mean that the grades themselves should be changed from year to year. To have value, such grades should mean the same thing each year to the trade, thus giving stability to the market. It does mean that fruit which may not pay in its proper grade in years of heavy production may pay well when so packed in years of shortage.

(5) *Size of Individual Crop.* The grower's procedure with regard to packages will be governed somewhat by the size of his own crop. With a short crop, he can give special attention to his packing, and to training resident laborers in improved packing practices. Such labor will then be ready to assist him in years of heavy production.

(6) *Where Crop is Marketed.* The export trade recognizes but three packages, the box, the barrel, and the bushel basket. When the grower uses his own local market, the number and type of packages that are acceptable increase considerably. Selection of packages must thus be made with the market in mind.

(7) *Specifications of Packages.* Barrel: The standard apple barrel possesses the following specifications:

Length of stave 28½ inches, diameter of head 17⅛ inches, distance between heads 26 inches, circumference at center 64 inches outside measurement, capacity 7056 cubic inches. Its capacity is thus somewhat more than 3 bushels. Federal laws require its branding "Min. Vol. 3 bu." A barrel of like capacity is also standard, though its dimensions may differ. An apple barrel is made of gum, oak, pine, poplar, birch, etc., the harder woods being more difficult to work by the cooper and not making as neat a package. The hoops are usually second-growth elm, six in number on the American barrel, two at each end and two quarter hoops. The Canadian barrel has eight hoops. Wire and iron hoops are used to some extent. The heads are of hard wood, preferably ash. A No. 1

barrel has 16 staves, free from knots, averaging 4 inches in width at the bilge, and heads of 2 or 3 pieces.

The barrel comes to the grower set up with heads and hoops in place, but without nails as a rule, although two nails are sometimes used to fasten each quarter hoop. The barrel can thus be stored until needed for use without danger of warping.

Box: The box is usually of spruce or pine and should be made up from sound, clean stock, dressed on the outer surface.

In the East the most common box is one which, when properly filled, contains 1⅛ bushels. It is not intended to be filled higher than the ends of the box or to become a closed package with a bulge on top and bottom like the Western box.

The New York and New England or Eastern apple box is 16 by 13⅝ by 11½ inches, inside dimensions. The ends and cleats are 7/16 inch thick, sides ¼ inch, and the tops and bottoms 5/16 inch thick.

The Western box is heavier for longer transportation. It is 10½ by 11½ by 18 inches, inside measurements. For odd sizes of fruit the special box, 10 by 11 by 20 inches, is used. One-piece ends are ¾ inch thick. Tops and bottoms consist of two pieces ¼ inch thick; sides of one piece ⅜ inch thick. Many firms furnishing box materials outside the commercial box regions depart from these specifications, but experience has demonstrated that changes, if made at all, should be made only within very narrow limits. Tops and bottoms must be thin enough to spring when the box is packed, thus making the bulge which insures a tight pack, automatically kept so by the tension of top and bottom. After packing, the boxes are piled on the sides. Boxes should be nailed, as dovetailed boxes have not proved satisfactory.

Boxes may be purchased either flat (Knocked Down—K.D.) or nailed ready for use, the first being the usual custom. Many local dealers in supplies have nailing machines and will nail the boxes more economically than the grower can do it by hand. The United States struck bushel (2150.4 cubic inches) is not adhered to in any type of box. The Western box contains 2173 cubic inches.

Bushel basket: This is a more inexpensive type of container which is very good for lower-priced fruit. Various makes and types of bushel baskets are available, including those having flat bottoms, stitched-in bottoms, removable bottoms, etc. The so-called continuous-stave flat-bottom baskets are desirable.

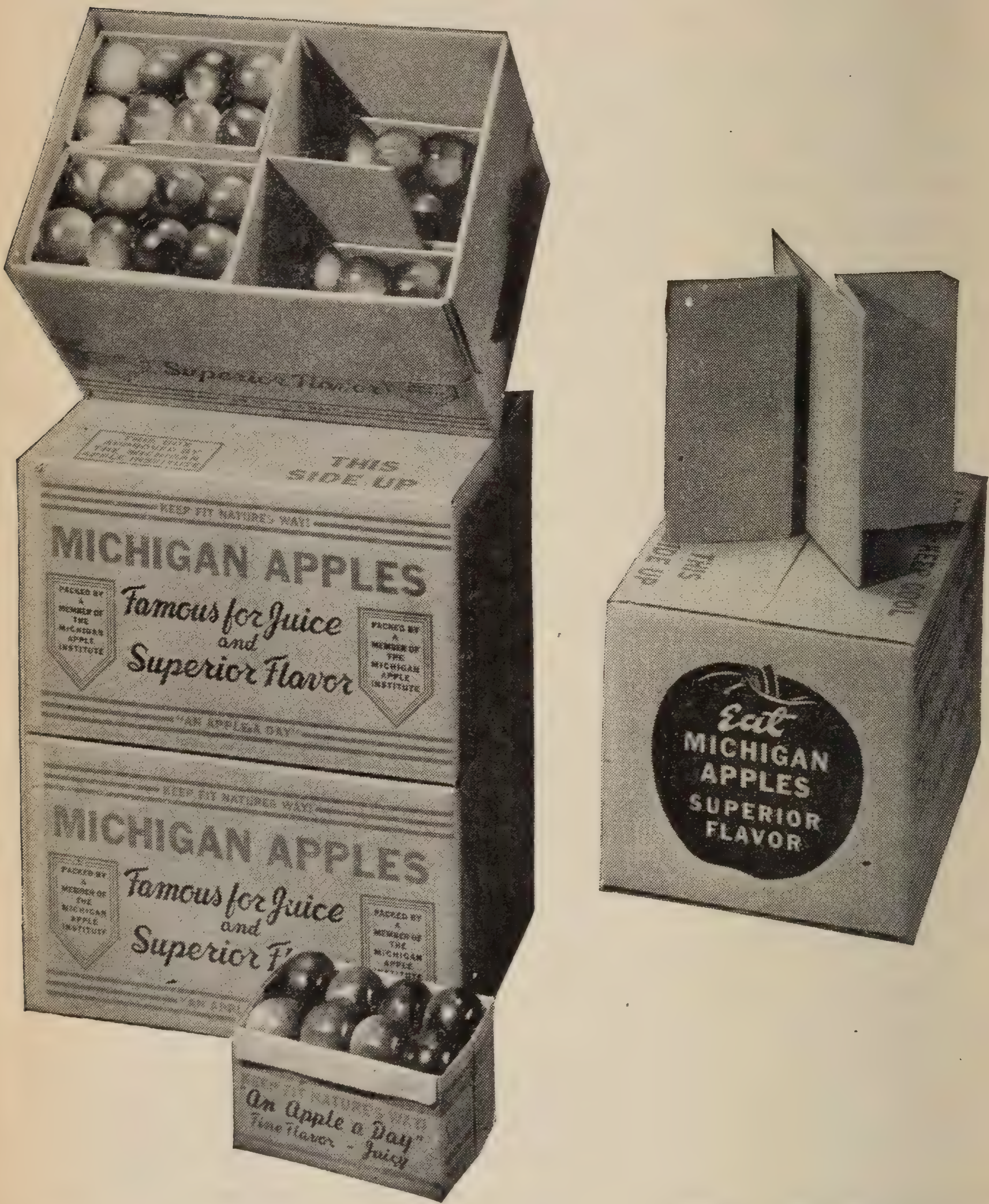
Paper and fiber cartons: There is no standard type of apple carton. Heavy paper or fiber board cartons vary in size from those which hold six apples to those which hold a bushel. Once the fruit is graded and sized these boxes may be easily packed. Through the use of decorative brands, colorful labels, and Cellophane tops they can be made very attractive (Fig. 6).

Some of these cartons have not remained sealed well after packing, especially when held in cold storage. Under extreme conditions, such as the presence of excessive moisure, they have lost their shape. Recent improvements have remedied some of their defects so that they are satisfactory in dry storage.

Hampers of various shapes and sizes are used for local trade, but have not met the requirements of the general market.

(*b*) *Determining Grades and Sizes to Be Made.* Some of the factors under determining the type of package to use have a bearing on this question. "Grade" refers to the exterior quality of the fruit, color, freedom from blemishes, firmness, and soundness. "Size" relates to the transverse diameter of the apple at its point of greatest circumference between stem and calyx. Size varies with the year and with the variety. A 2¼-inch Jonathan and a 3-inch Stayman may be equally high in grade.

Many states now have grading and branding laws. The grower should become familiar with those of his own state. Federal grades are also in effect and are now being adopted by many states and by the apple trade. These grades are known as U. S. Fancy, U. S. No. 1, U. S. Commercial, U. S. Utility, U. S. Hail Grade, and Unclassified. They represent a decided advance over former trade grades and introduce an element of stability in the market that is of advantage to all. In the absence of mandatory acts the grower who is intent



(National Container Assn.)

FIG. 6. These cartons make attractive packages and afford opportunity for advertising.

upon building a reputation as a dispenser of good fruit will wish to set high standards for himself. Many associations have rules and standards much higher than those of the federal and state grades.

Packing laws in some states require that closed packages must be labeled with the variety name, the name and address of the grower or packer, and the grade and minimum size of the fruit. This information must also be furnished when packing under the federal grades.

The following are samples of markings, which should appear on closed packages of apples grown in various states and packed for sale under some of the United States grades.

Barrel:

New York Apples
U. S. Fancy
Baldwin—2½-in. Min.
John Jones, Rochester, N. Y.
U. S. Std. Bbl.*

Ohio Apples
U. S. No. 1
Min. 2½-in. Rome Beauty
John Jones, Canton, Ohio
U. S. Std. Bbl.*

Carton:

Virginia Apples
U. S. No. 1
Stayman Winesap
John Jones
Winchester, Va.
This package contains
108 2-in. apples
Net weight...lbs.

Bushel:

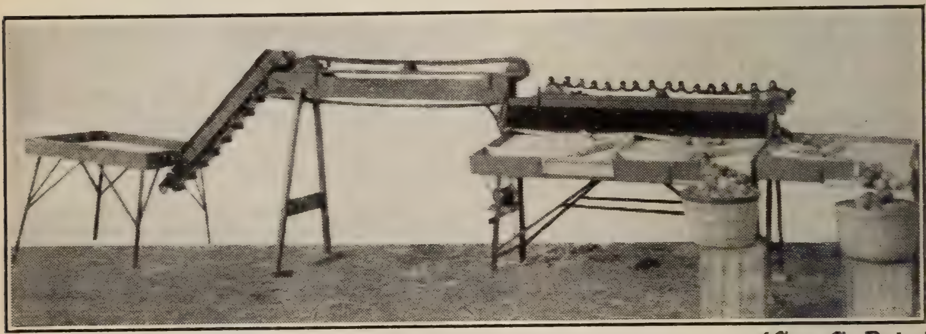
Maryland—U. S. No. 1
Delicious—Min. 2½ in.
John Jones, Frederick, Md.
Std. Bu.*

At the present time only the most tender-skinned fruits are sized by hand. There are a number of types of power-operated machines which size apples very rapidly and accurately (Figs. 7 to 14 inclusive). Uniformity in size as well as in other qualities plus quantity handling are now matters of prime importance. At present the tendency is to sort by means of mechanical devices into lots of several sizes with

* If packages are marked by the manufacturer "U. S. Std. Bbl." or "U. S. Std. Bu." such markings need not be made a part of stencil.

¼- to ½-inch difference between them, all apples being of the same grade and all uniform in size within narrow limits in a given package. The finished package looks better, and the buyer knows what to expect and can make his calculations better. The selling price is therefore more satisfactory.

The sizer should provide facilities at the hopper end for sorting the fruit for blemishes before passing it to the sizing section. Workers may remove defective specimens while the fruit is moving slowly on the conveyors en route to the various compartments. The sizing devices may be diverging belts

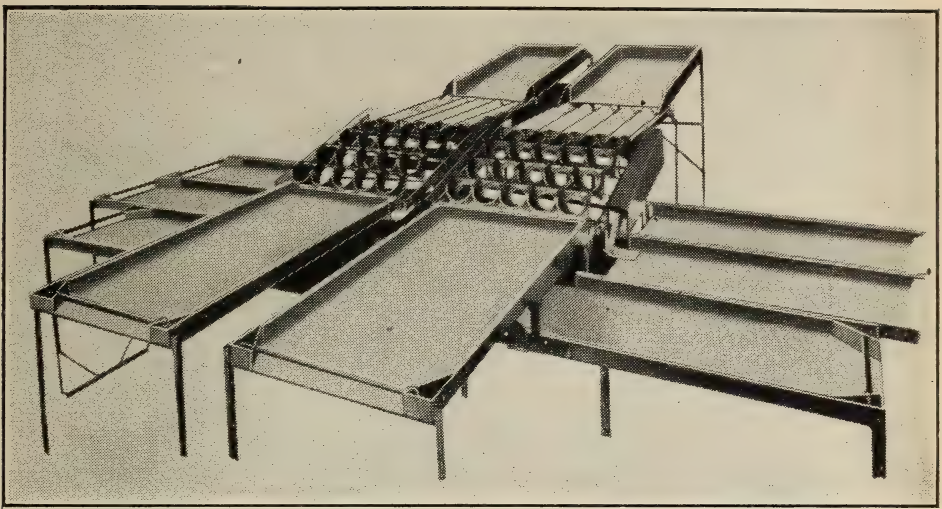


(*Geo. G. Bates*)

FIG. 7. A simple, but effective machine which both cleans and sizes the fruit. The cleaning device is a flexible bristle brush running over the top of the fruit. The sizing mechanism, the spiral rollers, directs the fruit to the various compartments.

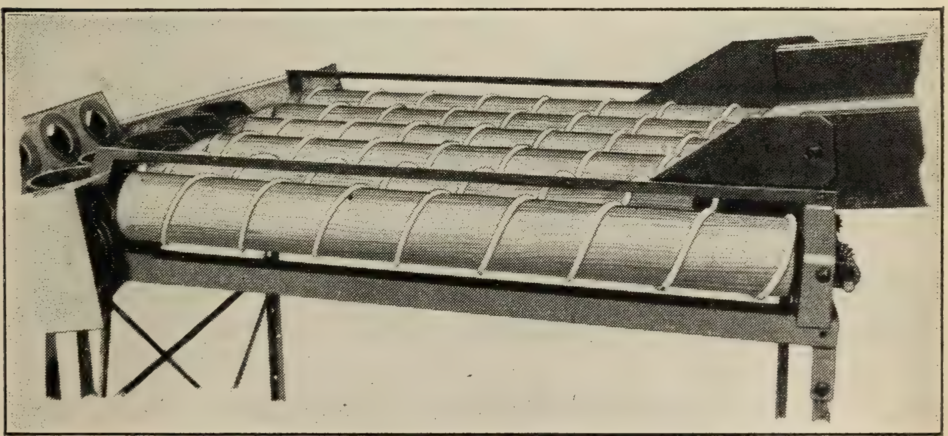
or spiral rollers, or rings or cups of varying sizes, dropping out the culls first, carrying the smaller sizes into side compartments and the largest size for which the machine is set to the end or the last compartment. The fruit is then packed from these compartments.

Western boxed apples are graded as Extra Fancy, Fancy, or C grade. The size is denoted by the number of apples in the box. Extra Fancy calls for the highest measure of perfection that can be attained commercially; Fancy allows for some tolerance as to color and slight imperfections; C grade takes fruit of less color and less perfect as to shape, etc., though still perfectly sound.



(*Butler Mfg. & Machinery Co.*)

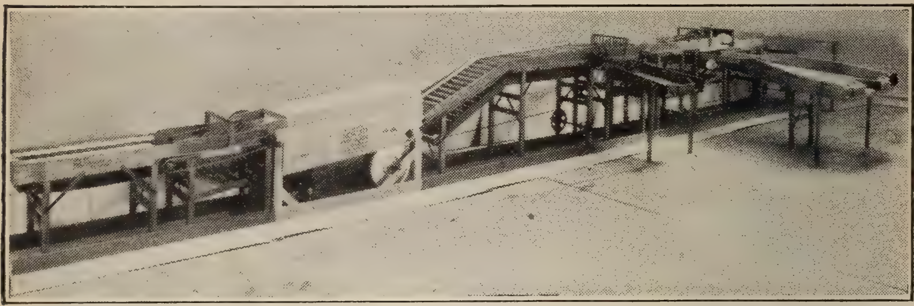
FIG. 8. The sizing device here is a series of rubber cups which pass, from one row of cups to another, apples which are too large to fit, the largest apples going to the end bins, the smaller ones passing to the side compartments. All compartments holding fruit are equipped with sponge rubber pads. Capacity as shown here is 100 to 130 bushels per hour.



(*Butler Mfg. & Machinery Co.*)

FIG. 9. A unit of rollers attached to the hopper of the machine shown in Fig. 8 to permit thorough inspection of the fruit before reaching the sizing cups. The spirals are soft cord. Revolving slowly, the rollers turn the apples eight to ten times.

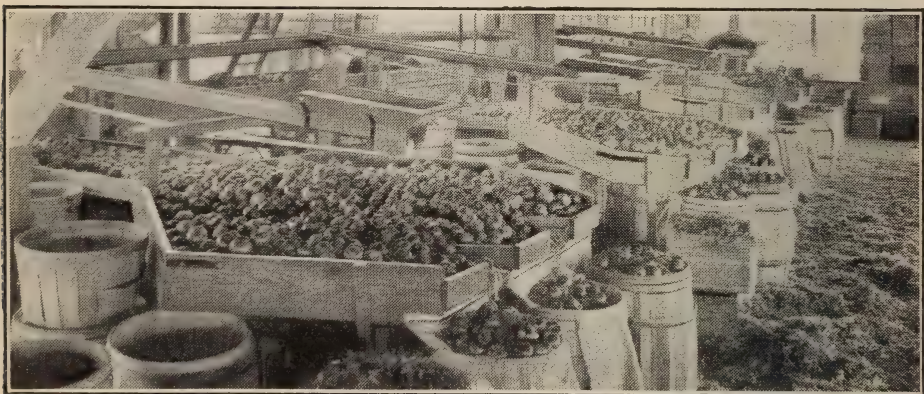
Eastern growers are seeking to retain the Eastern box for only high-grade fruit, disposing of the less desirable grades



(*The Trescott Co., Inc.*)

FIG. 10. This grader is equipped with a detachable cleaning mechanism. Small apples are removed as they leave the hopper. The others pass through the cleaner, on to the elevator and the sizing device, a series of rings of varying sizes, and thence to the packing bins.

in other ways. This is an effort that merits widespread support.



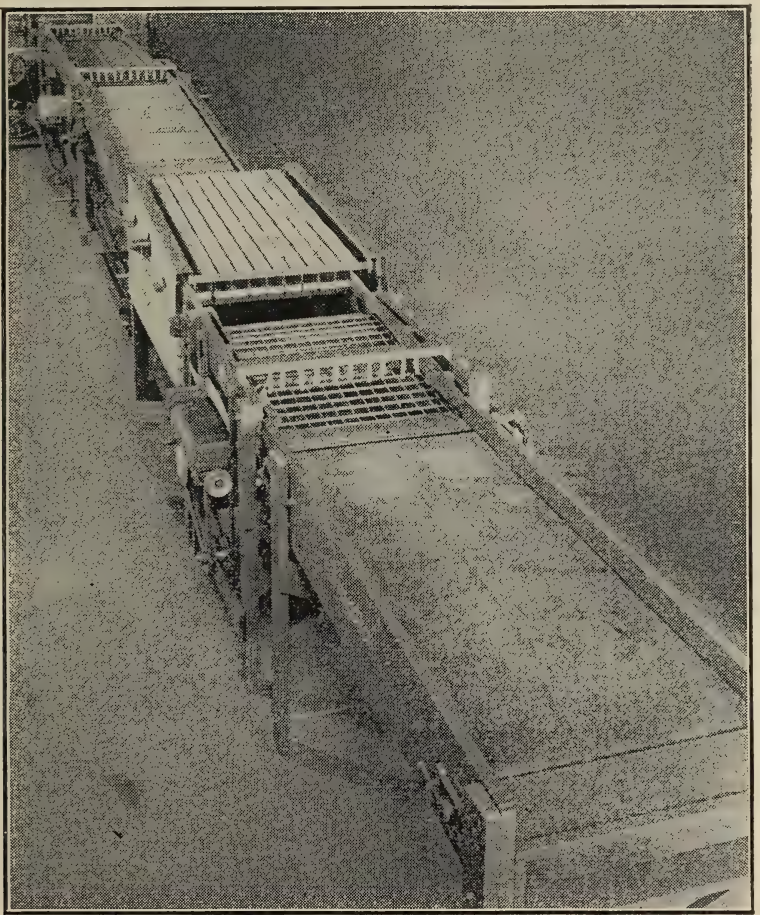
(*The Trescott Co., Inc.*)

FIG. 11. The machine shown in Fig. 10 in actual use in a Virginia packing house. Tender varieties should not be allowed to accumulate in such large quantities in the packing compartments.

Two grades and a varying number of sizes are commonly made of apples packed in baskets.

Table 3 gives the average grading records for a 5-year period for certain individual growers selling through a Michigan cooperative shipping organization.

Note the differences in run of crop between No. 13 and **No. 25.** Net prices to growers for bushel baskets during this

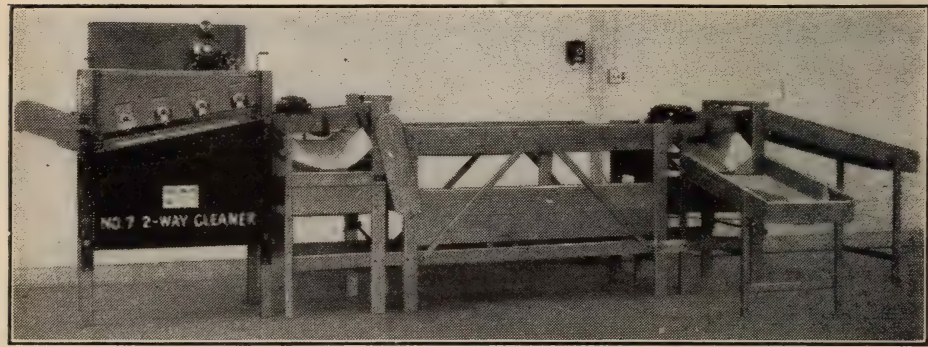


(Niagara Sprayer & Chemical Co.)

FIG. 12. Another make of sizer equipped with a cleaning section just beyond the first sizing unit which removes the cider apples. Hopper in the foreground.

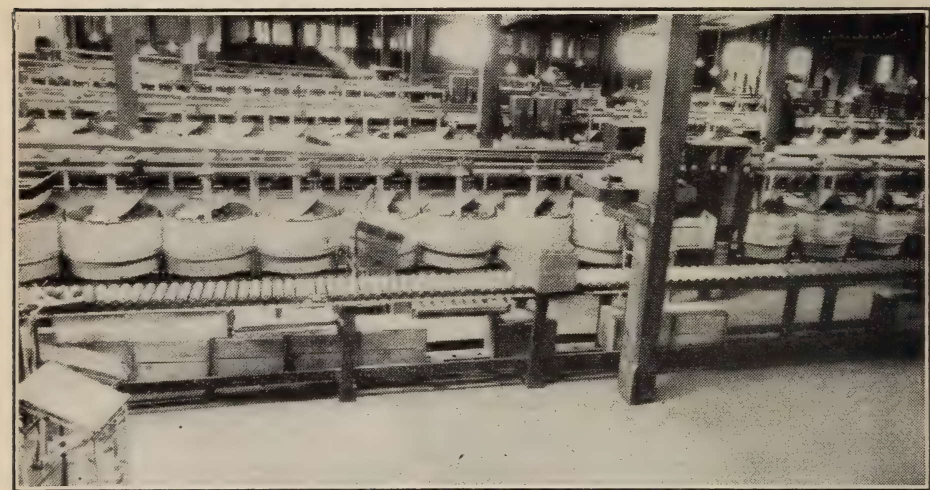
period were: A grade $0.90; B grade $0.56; C grade $0.16.

The causes of the poorer grades of fruit are indicated in Table 4, showing the percentages of specimens placed in B and C grades because of certain defects as between different



(*John Bean Mfg. Co.*)

FIG. 13. A cleaner and polisher consisting of a combination of brushes and cloth wipers attached to the sizing mechanism. The apples enter the cleaner at the left.



(*Cutler Mfg. Co.*)

FIG. 14. A battery of rotary bin sizing machines, separating the apples according to weight. Each machine has forty-four bins, making possible eleven separations for size in several grades from the standpoint of quality. At the lower left are two stands mounted on castors. The packers place their boxes on them, wheel them from bin to bin, wrapping each apple and placing it carefully but rapidly in the box. In the immediate foreground is a conveyor, the top section taking the packed boxes away, the lower section bringing the empty boxes back. Boxes are stamped with variety and grade designations and with the number of apples in the box. Lidding presses fasten the covers. Each machine has a capacity of 200 packed boxes per hour.

TABLE 3

APPLE GRADING RECORD OF MICHIGAN GROWERS' SELLING THROUGH A COOPERATIVE*

(Five-Year Period—in Percentages)

Number	*A*	*B*	*C*	Canner	Unclassified	Bulk
1	57	22	9	5	6	1
13	74	13	9	0	0	4
25	24	7	10	0	0	59
28	30	30	28	3	2	7
29	22	32	41	3	0	2
70	70	17	10	1	0	2

* V. R. Gardner, *Proceedings, N. Y. State Horticultural Society,* 1928. From *Mich. Special Bul.* 160, by H. P. Gaston.

TABLE 4

CAUSES OF LOW GRADES OF APPLES*

Variety	Injury	B Grade		C Grade	
		Grower 1	Grower 2	Grower 1	Grower 2
		Percent	*Percent*	*Percent*	*Percent*
McIntosh....	Scab	70.3	7.1	60.6	6.8
King........	Stings	45.5	20.2	28.3	10.0
N. Spy......	Bruises	47.3	14.4	44.7	8.4
Greening.....	Limb rub	58.7	24.1	73.7	14.5
Baldwin.....	Size	94.4	63.0	90.3	44.4

* V. R. Gardner, *Proceedings, N. Y. State Horticultural Society,* 1928. From *Mich. Special Bul.* 160, by H. P. Gaston.

growers and different varieties. For instance, of all the McIntosh of Grower 1 that were placed in B grade, 70.3 per cent were so placed because of scab. Cull fruit adds greatly to packing costs and is worth nothing in itself.

It is evident that most of the causes of off-grade fruit are preventable by better orchard practices and greater care in handling. Thinning, care in spraying and handling the fruit, proper fertilization of the soil, and adequate pruning all have their influence.

(*c*) *Determining Where Packing Is to Be Done.* The grower may pack his fruit (1) in the orchard, (2) in his own packing house, or (3) in a community packing house.

(1) Orchard packing was at one time the most common procedure in the East. The operation is subject to interruption by the weather; it is not possible to have as adequate facilities or those so conveniently arranged as in a stationary plant. It may not be feasible with the large quantities of fruit now grown by single individuals.

Something can be said, however, under certain conditions for orchard packing. The emphasis now is on handling the fruit as little as possible. Some growers of McIntosh have found it desirable to pack in the orchard directly from the containers which the pickers have deposited. They set up their boxes into which the fruit is to be packed on portable tables of simple design between the tree rows (in the shade, if the sun is hot), size and grade the fruit by hand, place the packed boxes in the shade, and move along with the picking gang. The packed boxes are picked up by truck and taken to their destination. One or more units of this type may be set up. The procedure works well if properly organized.

(2) Use of the grower's packing house follows the present general tendency toward packing fruit in central plants rather than in the orchards. This is a practice long followed in the West. Work may thus go on in all kinds of weather if a supply of fruit is picked ahead for such emergencies. More

suitable packing equipment can be installed, including better packing tables and mechanical sizers, and the packages may be kept under cover at all times. With increasing competition from all sections, greater care in packing becomes absolutely essential. This factor, together with that of greater rapidity in grading, has stimulated the development of the packing house and the use of mechanical devices.

(3) The community packing house is a further development. The grower may deliver his fruit and leave the grading and packing to be done there, at a certain charge, while he gives all his attention to harvesting the crop. This is the custom packing house, common in some sections.

Packing houses, operated on a cooperative basis, are now found in many sections, including Nova Scotia, New York, Pennsylvania, and other Eastern states, as well as the Pacific Northwest. They make possible the packing of a large quantity of fruit of a certain standard, which greatly facilitates its marketing. They allow the individual grower to confine his attention to getting the crop off the trees in good season and to the packing house in good condition. They make possible the growing of a larger quantity of fruit by the individual because he does not have to concern himself with the packing.

These community houses may be federated into a central organization which undertakes to handle the marketing, to purchase supplies, etc.

How a Cooperative Packing House Operates. Though there are variations in methods, a typical packing house operates as follows: The fruit is delivered tree-run at the packing house by the grower. Containers are stamped with the grower's number, and a receipt is issued to the grower giving the number of the containers and the varieties delivered by him. The fruit is graded and sized into ¼- or ½-inch sizes, and packed, each grower's fruit being run separately. The number of packages of the various grades and sizes and the number of pounds of culls are entered on the association's books, after which the fruit frequently loses its identity from the grower's standpoint.

In some places, instead of grading all the fruit of an individual grower separately, a few sample bushels are graded by hand from each load which he brings in. The balance of the load is estimated according to the findings of the sample. This avoids running small lots through the sizers, recording them, and clearing the machines before starting with a different lot, thus saving considerable time and increasing the output of the packing crew.

Returns are usually made on the pool basis, a pool extending through all or part of the season, being made for each variety, grade, and size. A grower receives the net price after packing charges are deducted, constituting the average price for the pooling period for the variety, grade, and size in question. The accounts cannot be completely cleaned up until the season is over, but advances are made to the grower in the meantime, only a small balance remaining at the close of the season.

Instead of pooling the fruit, that owned by each grower may be sold separately and returns made on his own product.

Although the packed fruit is usually sold by the association, it may be sold by the grower. In any event he pays all the costs. Packing costs are determined by taking the total cost of labor, supplies, depreciation of buildings and equipment, insurance, and interest on investment, and prorating them on the basis of the quantity of fruit brought to the packing house by each grower. The charge is thus made against unpacked rather than packed fruit. This is fair, since packing costs are as high on 100 bushels of tree-run fruit which sort out 50 bushels of culls and low-grade fruit, as on 100 bushels which pack up 70 bushels or more of high-grade fruit. This plan also stimulates the growing of good fruit and the keeping of poor stuff away from the packing house.

It is evident that volume is a very essential factor for successful cooperative effort. Packing costs decrease very rapidly in every detail with increase in volume.

Requirements for a Good Packing House. Such a packing house should have adequate facilities for receiving fruit without keeping the drivers waiting to unload, and for accumulating a reasonable supply to pack when the weather prevents hauling. It must be well lighted over the sizers and packing tables and efficiently arranged for handling the fruit. Conveyors should be installed for carrying culls out of the way, for transporting empty packages, and for moving the packed fruit. Storage space should be provided for at least part of the season's supply of packages and for holding the packed fruit until a carload is ready, unless the fruit can be loaded immediately into cars standing on a side track or can go to cold storage by truck.

A loft for empty packages and supplies, a well-lighted first floor for the packing operation, and a basement for the packed fruit make a good arrangement. Such a house would need to be built on a slope so that the first floor and basement might both be at ground level. Ventilation in the fruit room is important. Instead of storing packages in a loft, some growers prefer to store them in an adjoining building, and through the use of skylights make more light available to the packing floor (Fig. 15).

Floor plans of desirable houses for barrel and box packing may be obtained from the United States Department of Agriculture.

(*d*) *Grading.* In grading U. S. No. 1 fruit, whether by hand or machine, discard all apples showing limb rubs, spray burn, sun scald, russeting, hail, visible water core, disease, or insect or mechanical injuries, and fruit which is overripe or out of condition. A small proportion of these defects is allowable, but some fruit possessing them will remain even though the operator removes all that he can find. He should seek to pack well above the minimum grade standards. Handle the fruit with the greatest care. Do not press or drop it.

Be familiar with the grade requirements (see General Information at the close of this chapter) as to color and size. Keep sample specimens in view until proficiency is attained. Use both hands, and strive constantly for greater speed and accuracy. Look at the apples as they lie on the table. Pick them up in such manner that as the wrists turn the undisclosed portions of the fruit come into view. Most mechanical sizers turn the fruit on the rolls or belts to afford opportunity for thorough inspection—an opportunity which is often neglected.

(*e*) *Packing in Barrels.* Inasmuch as very little fruit is now packed in barrels and that almost entirely for export, the subject is treated under General Information at the close of this chapter.

(*f*) *Packing in Western Boxes.* The box has become the standard package for apples. In the West and in British Columbia it has been the universal package for many years.

FIG. 15. (*a*) A western New York community packing house. The fruit is received at the left, packed through the house, and loaded on a railroad siding at the right. Two doors for unloading or for removing culls are available around the left corner. The lighting arrangement for packing is very poor. (*b*) This is a Maryland packing house. The packed fruit goes onto cars at a lower level on the right. The lighting is excellent. A storage for packages is just out of the picture on the left.

A large measure of attention to individual trees reduces to a minimum the proportion of fruit that is medium or below in size, color and perfection, and increases correspondingly the proportion of high-grade fruit. This does not mean that culls are unknown in good fruit regions. The disposal of fruit too poor to box is one of the serious problems confronting the box apple territory.

(1) Grading the Fruit: The fruit must be very carefully graded as to size, shape, and color, fruit blemished by insect or disease being discarded as required by the grade terms. Definite styles and types of packs based on long experience have been worked out. The trade desires to know the number of apples in each box.

Standard numbers have been determined for apples of a certain size, packed according to a certain style. It is therefore evident that there must be little variation in size between the individual apples.

Mechanical devices are used very extensively for sizing, though much fruit is still graded by hand. The machines perform the work more quickly but unless operated with great care may injure the fruit more than hand sizing by experienced workers. Machines should provide ample space for removing inferior fruit before the sizing mechanism is reached.

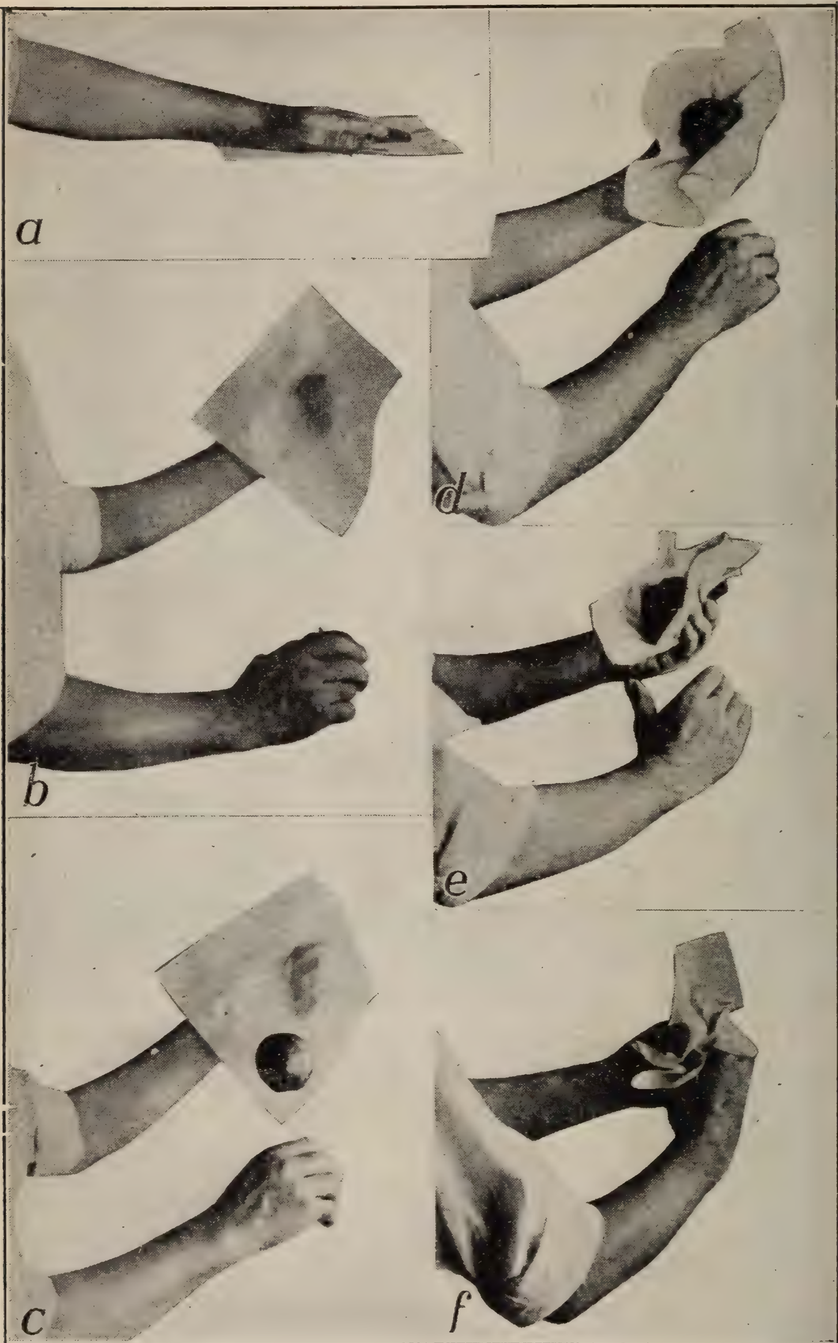
(2) Supplies and Accessories: Specifications for the box have already been given in connection with "Determining the package to use."

A bench upon which to make the boxes, with nail box, automatic nail stripper to enable the workman to get hold of the nails, and a box hatchet, will be needed. For the wrapping paper, a hod that clips to the box or packing stand is necessary. A clip under spring tension will hold the paper in place and release one sheet at a time.

Nails—Four- or five-penny, cement coated or waxed, 8 nails for each side, bottom and top, 32 nails to the box.

Cleats—Used on each end of top and bottom. Drive through cleats when nailing top and bottom. Soak cleats if inclined to split.

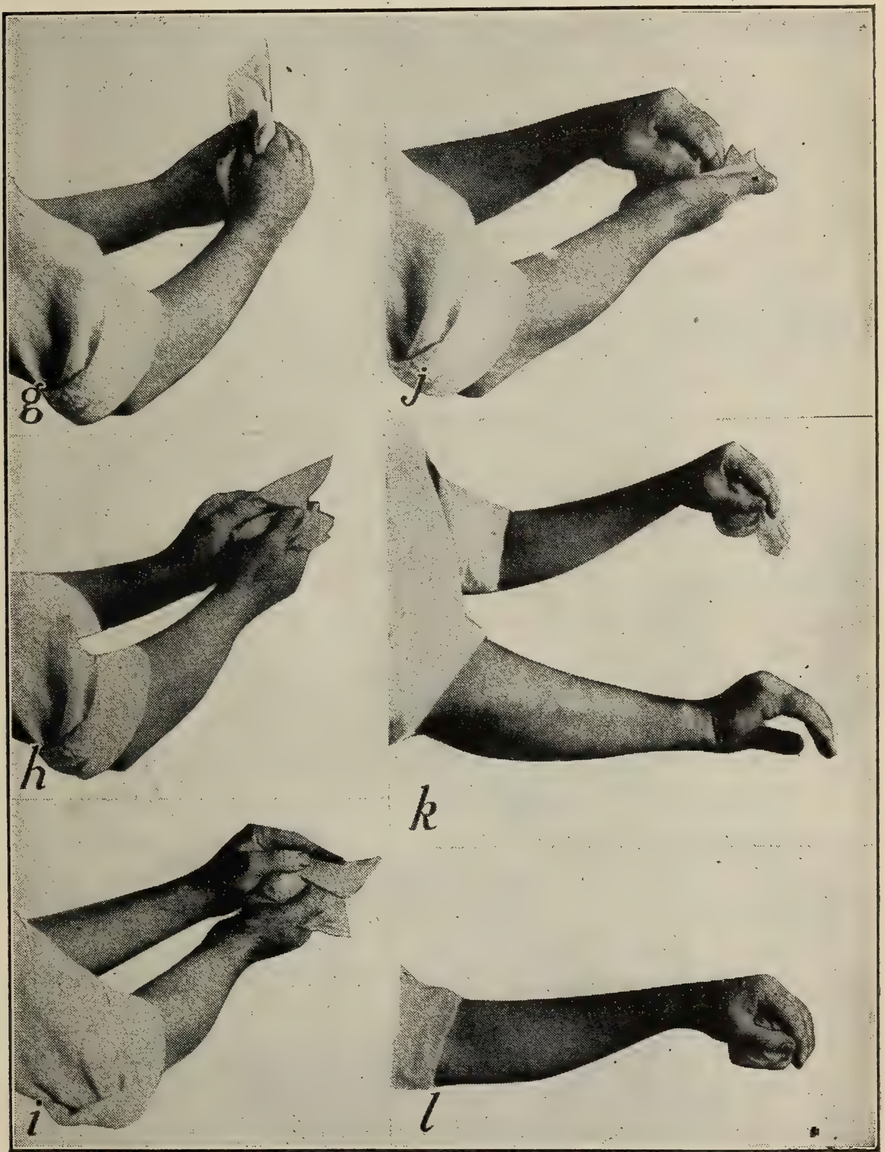
Lining paper—Used for all except poorer grades of fruit. Blue for Extra Fancy, pink for Fancy, white for C grade, of 23-pound news grade or 20-pound sulfide, two pieces per box, each piece 17½ by 26 inches. Put in the pieces, so as to overlap on bottom with a slight



(U. S. D. A.)

Fig. 16. There are several satisfactory ways in which to wrap an apple. This shows the various steps employed in one method.

fold along bottom edges to afford slack which will be taken up when the cover is put on, without tearing the paper. After the box is packed, the top edges are folded across each other.



(*U. S. D. A.*)

Fig. 17. Wrapping an apple, continued from Fig. 16.

Wrapping paper—Paper now commonly used is 12- or 14-pound glazed on surface away from fruit. Wrapped apples pack more easily than unwrapped, are protected from injury and decay, and give evidence of care in preparing the package for market. The size of the paper varies with the size of the fruit. Wraps for the largest apples are 12 by 12 or 14 by 14 inches; for apples running 64 to 80 to the box, 11 by 11 inches; 88 to 113, 10 by 10 inches; 125 to 180, 9 by 9 inches, for smaller sizes 8 by 8 inches, though such sizes are sometimes packed without wrappers. The wraps may be stamped with the brand or trade mark. Oiled wraps are largely used for varieties that are to be stored, as indicated under "Storage Scald."

Stamps—After the fruit is packed, the name of the variety, the grade, the number of apples in the box, and the minimum net weight are stamped in purple ink on the end of the box above the label. Assorted stamps will be needed for these purposes. Stamping machines that ink themselves are used in some packing houses.

Labels—of different colors depending on the grade of the fruit are commonly used. Blue for Extra Fancy, pink for Fancy, and white for C grade are standard colors. These labels have been worked out in simple and attractive designs and combinations. They are pasted on the ends of the box, and are of such size as to leave about a ½-inch space at the top for the stamping. A high grade of paste is used. As a matter of economy, many labels are now put on before the boxes are made up.

(3) Wrapping the Apple: No two persons wrap an apple in exactly the same manner. It should be kept in mind that, since the whole process has to occur with every apple packed, it is vital that every unnecessary motion be eliminated. This calls for much practice and precision. When the operation is completed, the loose ends of the paper should be folded neatly under the apple as it lies in the box. See Figs. 16 and 17.

The diagonal pack (Fig. 18) is commonly used, because it is easier to pack, the fruit fits snugly together, the finished pack remains tight longer, and there is less danger of bruising. In this style of pack the apples are always placed in spaces between apples rather than directly over or against them. It will be found possible by packing the fruit either on the side or end to use the diagonal pack in nearly all cases. The 2-2 or 3-2 diagonal packs will take most commercial sizes of fruit. The largest sizes may have to be packed 2-1, and the small sizes 3-3. Diagrams in *Farmers' Bulletin* 1457 illustrate types of packs, number of layers and of apples in a layer, and the number of apples in the packed box.

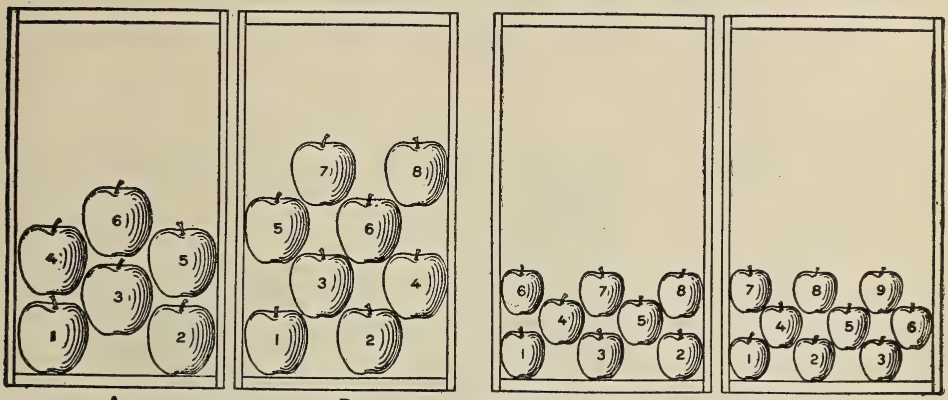
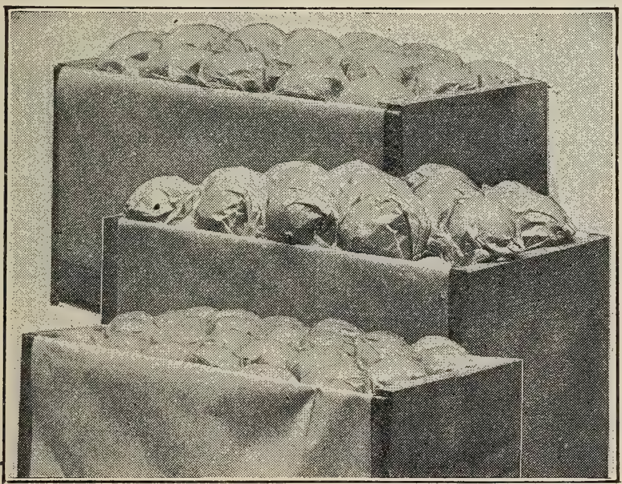


Fig. 18. The diagonal pack adapted to apples of varying sizes.

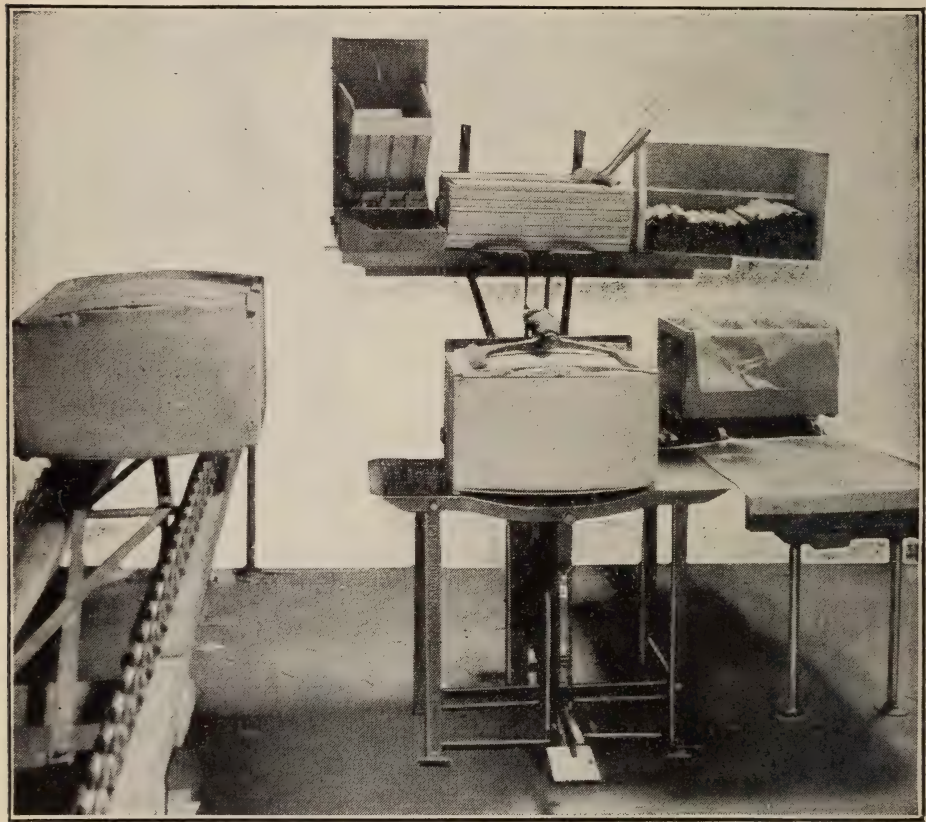
Start the pack against the lower end of the box nearest the packer, the box being tilted so that the fruit will remain in



(*U. S. D. A.*)

Fig. 19. The upper box illustrates correct height and bulge; the center box is packed too high; the lower box too low.

place. Great importance attaches to getting the initial layer in place correctly with no free space between the last apples and the end of the box. The medium and small sizes may be tightened in the layers considerably by pulling the layer toward the packer, from time to time in the packing process. The larger sizes should fit well, but should not be tightened much as the bulge in the finished box may be too high.



(*U. S. D. A.*)

Fig. 20. A desirable arrangement for nailing the covers on boxes. The press is simple and easily operated from the foot pedal. The boxes to be covered come to the press on a conveyor at the right, and after nailing are set on the conveyor at the left.

Carry each layer through to completion before starting another. The packer will need to make adjustments and selection so as to have the fruit about ½ inch above the ends of the box and about 1 inch above the sides at the center when the pack is completed (Fig. 18). The bulge should be gradual and uniform with no sags or low apples, reaching its highest point at the center, so that when the cover is nailed the package will be springy and tight. With most varieties it will help to secure the proper bulge if the packer places the apples in each row and each layer that are adjacent to the ends of the box on end rather than on the cheek, so that their diameters build up the height of the pack less than do the apples in the center.

In addition to nailing the cover, boxes intended for export should be wired at the ends.

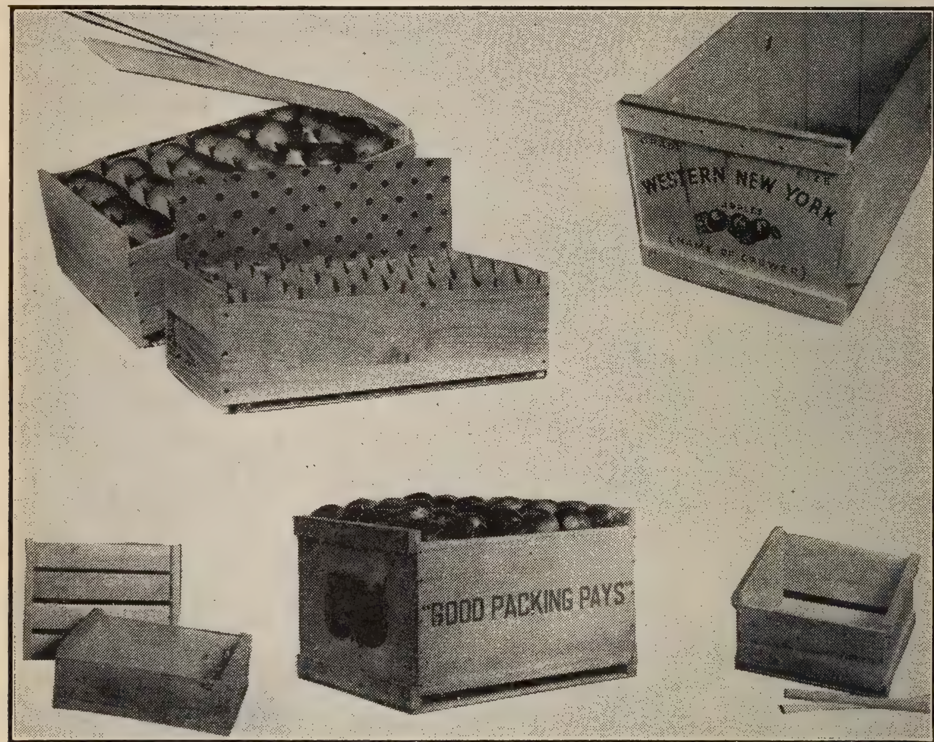
(*g*) *Packing in Eastern Boxes.* As a rule the fruit in the Eastern box is not wrapped. The apples are placed in the box by hand, the box is shaken several times to settle the fruit, the top layer is made as orderly as possible, care being taken not to elevate the fruit above the ends of the box. A colored paper cover is placed over the fruit and nailed in place by slats across the ends. The boxes may then be piled on trucks or in storage without damage to the fruit.

It is well to use oiled paper if the fruit is to be put into storage, as indicated under Storage Scald, page 66.

In packing the box, facers are sometimes used on the top of the box. By attaching the facer first, turning the box upside down, packing the first layer, filling the box without placing the fruit in layers, nailing on the bottom, inverting the box, and removing the facer, it is possible to have a very good-looking pack with a minimum amount of labor. The use of a cardboard cover instead of the facer makes a very solid package. This cover is nailed in place by two narrow slats and then the box is filled in exactly the same manner as when an ordinary facer is used.

A successful grower of fine apples in the Hudson Valley section of New York gives these directions for packing the box:

In the construction of the box, omit the nailing of the bottom but instead nail the two slats on the top. Invert the box ready to face and fill. Place a corrugated paper sheet, 14 by 16¾ inches on the slats, then two pieces of a heavy tough crepe paper, blue in color, or a heavy white wax paper on the corrugated sheet. Place the paper so that it can be folded over the sides, leaving enough margin so that when the box is filled the paper can be brought back over the fruit before the bottom is nailed on. Thus the box is lined top, bottom, and sides but not on the ends.



(*New England Box Co.*)

Fig. 21. Types of apple boxes used for Eastern apples. The box in the center foreground is standard. It has, however, been packed a little too full. When the paper cover has been placed on the fruit, and the slats nailed in place, it should be possible to pile the boxes without bruising the fruit.

The second part in the process is the facing. The fruit used is as uniform as to size and color as the grade will permit. The cheek pack is used, keeping the color side up, and the fruit is packed as tightly as is possible without bruising.

As fast as graded, place the fruit on the face, being careful to bring the fill up level, although not placing the fruit in exact layers. When the box is full, slightly above the ends, fold the paper over the fruit and put the bottom board in place. With each hand hold the bottom and slightly shake the box settling the board in place. Nail the bottom, turn the box, and the job is done. Pack this box good and tight but with no bulge whatsoever.

The Eastern box is not intended to duplicate the one used in Western sections. It is designed to provide a convenient and attractive package of fine fruit at a minimum of cost, the saving being made not in quality of the fruit but in labor. It is growing rapidly in popularity. It does need further standardization.

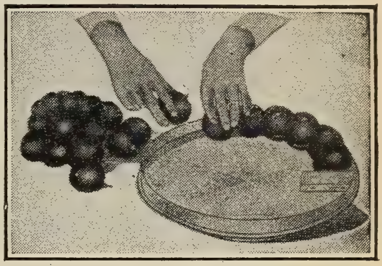


Fig. 22. Placing the apples in the facer for packing in baskets. Some facers are furrowed or corrugated to keep the rings of fruit in place; see Fig. 23.

(*h*) *Packing in Baskets.* A good way to pack a basket of apples is to prepare the face first on a metal plate or device which holds the fruit in place (Figs. 22 and 23). When the face is completed, slip over it a metal follower inside of which is a heavy paper liner of the same depth and circumference as the interior of the basket. Run this liner full of the apples. Remove the metal follower. Slip the basket top down over the fruit until the edges of the basket are pressed against the metal

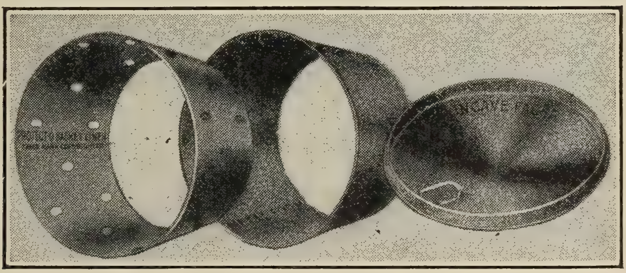


Fig. 23. At the right is the facer; in the center is the metal sleeve which sets on the facer and is run full of fruit; at the left is the paper liner used inside the metal sleeve and remaining about the fruit when the sleeve is removed.

plate holding the face. Turn the basket over, release the facing device, and put the cover on the basket.

The whole operation may be performed very quickly. In large establishments, workers place the facers and send them along on conveyors to others who place the followers and fill the baskets. Mechanical devices for reversing the baskets after they are filled hasten the operation and save hand labor (Fig. 24).

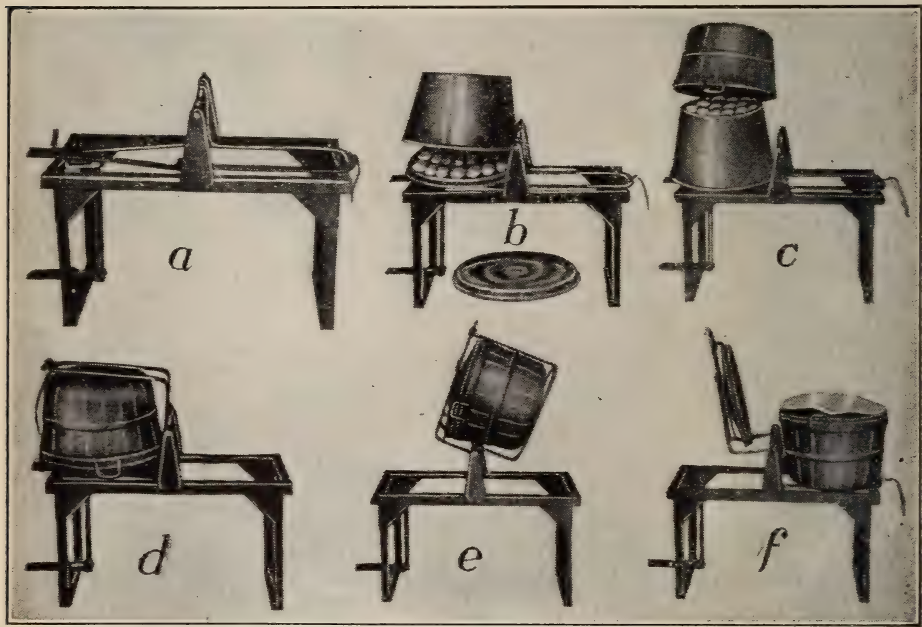
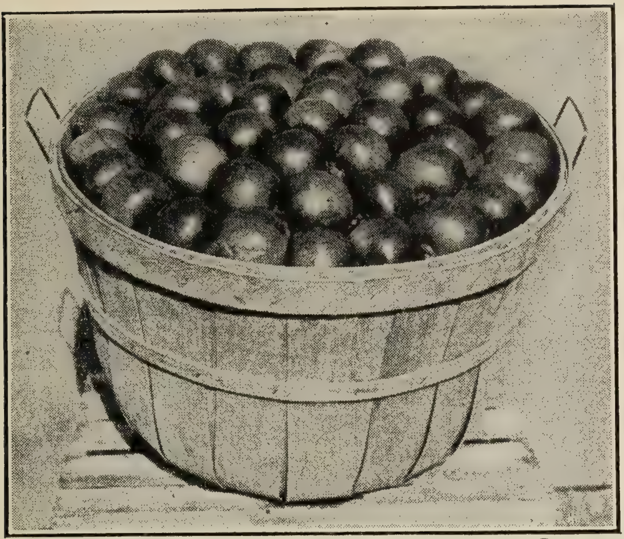


Fig. 24. The various steps involved in packing a basket and preparing to attach the cover. Several types of basket turners are available. The fruit is brought to the turner as indicated at *c*. Note the paper cap at *f*.

Facers on their cheeks and in concentric rings make a very attractive package. Use a corrugated paper pad under the cover. The finished basket should have sufficient bulge or spring to the cover to hold the fruit firmly in place and to constitute a full pack when it reaches the market (Figs. 25 and 26).

(*i*) *Removing Spray Residues.* In sections where heavy applications of arsenicals must be made for the codling moth,



(*N. Y. State College of Agr.*)

FIG. 25. A well-faced basket. The fruit is higher at the center than at the edges of the basket, insuring a light, springy pack.

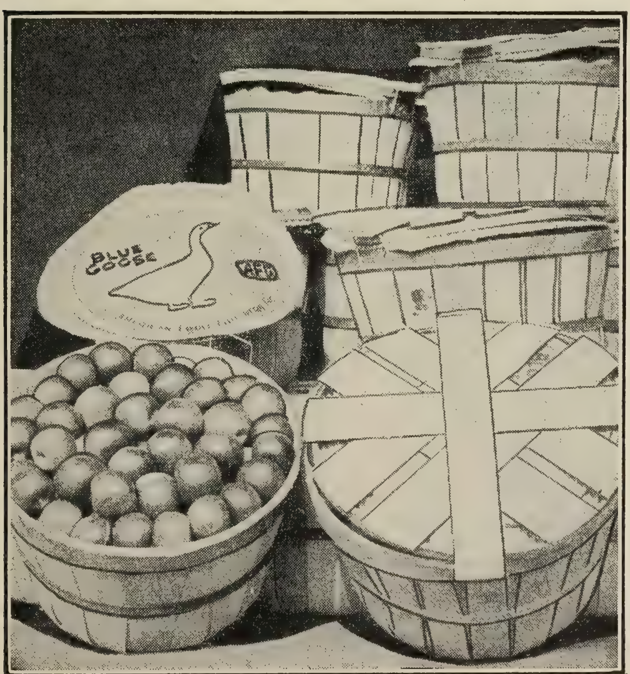


FIG. 26. Note the strong well-made covers, the bulge of the covers making a tight pack, and the trade brand inserted in each basket.

especially if these are made late in the season, a considerable residue of arsenic and lead remains on the fruit at harvest time. Authentic cases of illness from eating fruit carrying these residues are difficult to find. Nevertheless, it is to the advantage of the grower to have his fruit as free as possible from such residues and to find substitute spray materials which are effective but of a non-poisonous nature. The present regulations of the Federal Food and Drug Administration do not permit more than 0.025 grain of arsenic trioxide, 0.05 grain of lead, or 0.02 grain of fluorine per pound of fruit. Certificates indicating amounts of residues are now issued by regulating agencies in the various states. Notices sent to growers take the following form:

STATE OF NEW YORK
DEPARTMENT OF AGRICULTURE AND MARKETS

HOLTON V. NOYES, *Commissioner*
ALBANY

WESTERN DIVISION
STATE OFFICE BUILDING, BUFFALO, N. Y.

LEON D. SPINK *February 5th, 1940*
District Supervisor

H. B. KNAPP
Farmingdale
Long Island, New York

Dear Sir:

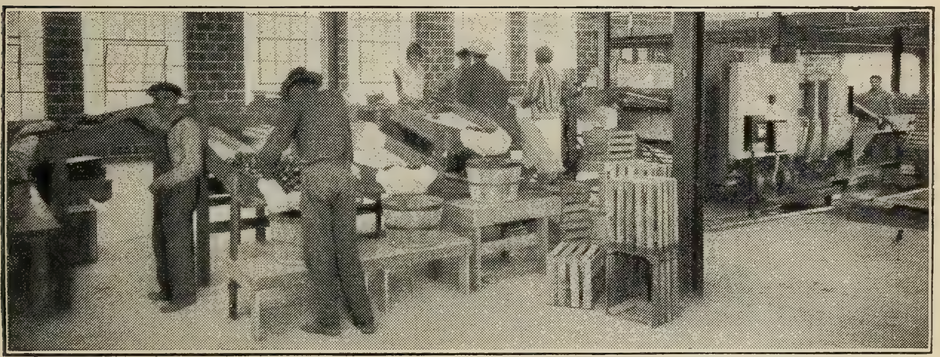
This is to advise that sample A-40436 taken on February 5th from 400 bushels of McIntosh apples owned by you and stored in the Savannah Cold Storage has been found to contain .004 grains of arsenic and .009 grains of lead per pound.

Certificate No. 8355 covering this lot of apples has been mailed to the Savannah Cold Storage.

Very truly yours,
(*Signed*) L. D. SPINK
District Supervisor

Intensive efforts and investigations have been under way for several years to devise solutions for the problem within the financial means of the grower and not harmful to the fruit. Further developments should be watched with interest in those sections where spray residues constitute a serious problem.

It has been established that dry wiping, whether by hand or machine with brushes or otherwise, is not effective in removing more than one-third of the residue, even under the best conditions. Considerable mechanical injury results, and the residues in the blossom and stem ends cannot be removed in this manner.



(*John Bean Mfg. Co.*)

Fig. 27. A fruit washer (right) connected with the sizer.

The most satisfactory method developed to date is to treat the fruit (apples and pears) with a bath of dilute hydrochloric acid. Machines have been developed for this purpose (Fig. 27), including satisfactory home-made machines.

One type of machine sprays the fruit with diffused jets of the solution as it passes through the spray chamber, rinsing the fruit later with clear water and drying it with a forced draft of air. A second type floats the fruit directly through the solution, spraying the fruit from nozzles at the same time, rinsing and drying later. Other types are in use.

The commercial machines may be too expensive for the small grower. Some home-made machines costing not more than $100 have proved satisfactory. One of the best of these consists of a tank equipped with paddles which both propel the fruit and immerse it slightly. This device is not satisfactory for pears since most varieties sink to the bottom of the tank. A better device for pears is a belt conveyor which carries the fruit along, partly immersed in the solution.

It has been possible to remove as high as 90 per cent of residue under commercial conditions.

Efficiency of the treatment is increased by increasing the strength of the acid, increasing the time of exposure, and especially by raising the temperature of the solution. Varieties with oily skins are most difficult to clean. Best results are secured by treating soon after picking.

Residues of lime, copper, lead, etc., are removed at the same time. Very slight detrimental effects on appearance or keeping quality have occurred on sound fruit when the operation is properly performed. Some varieties have calyx tubes extending well down to the core of the apple. In the machines submerging the fruit, it has not been possible to remove the cleaning solution from these tubes, and some damage to the tissues, sometimes followed by decay, has resulted.

Careless cleaning methods may result in arsenical injury at calyx or stem, or hydrochloric acid burning, or chemical injury at the core. Any of these injuries may result in storage rots. All decayed fruit should be kept out of the cleaning equipment.

The commercial grade of acid testing 20 degrees Baumé is satisfactory, 3 gallons in 100 gallons of water making approximately a 1 percent solution, by weight. Solutions containing about ½ of 1 percent are commonly used except in aggravated cases. The strength of the acid bath should be maintained by additions of acid from time to time. Clean the acid tank completely each day to prevent the accumulation of soluble arsenic.

Rinsing is very important in preventing injury to the keeping quality of the fruit. Two to 3 gallons of fresh water should be used for each bushel of fruit treated. If the supply of water is limited, the same water may be used repeatedly, provided that sufficient lime is added to neutralize the acid.

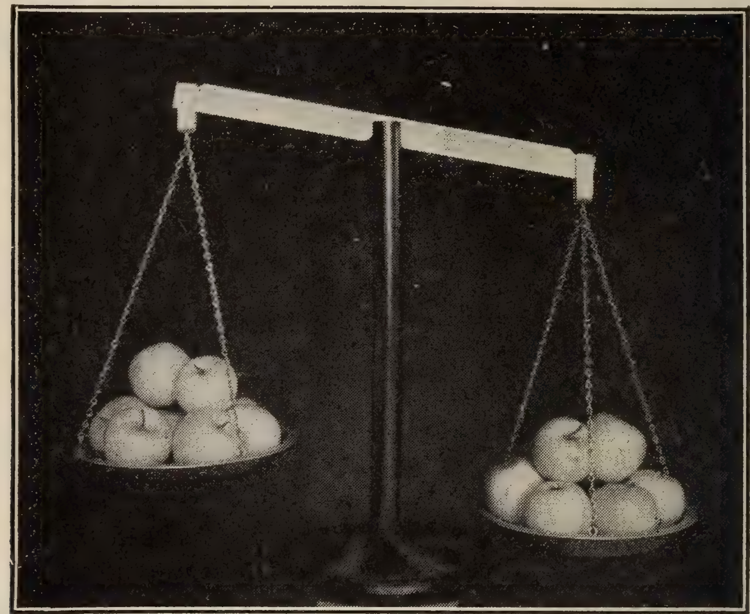
(*Brogdex Co.*)

FIG. 28. A waxing outfit. The curved metal shield directs a sheet of wax over the revolving fruit. The machine has a capacity of 300 bushels per hour.

Complete drying of the fruit does not seem to be necessary.

Alkaline washes have been used and experimental work done with the application of paraffin and oil following the treatment, to replace the natural wax removed in the process. Wax emulsions, diluted with water, are used to advantage if the fruit is to be stored for any length of time (Figs. 28 and 29). Developments in this field may well be watched closely.

3. Determining Harvesting and Marketing Costs. The cost of picking apples depends upon the topography of the ground, the size of the trees, the variety, the yield, the cost



(Brogdex Co.)

Fig. 29. The apples at the right were waxed before going into cold storage. The others of the same weight and variety from the same grower were not. The photo was taken after ten days at room temperature. The loss in weight is about 1½ pounds per bushel.

of labor, the efficiency of equipment, and whether picking is done by the box or by the day.

The cost of hauling to storage, grading, packing, storing, and marketing depends on so many factors that available figures, though specific for one instance, are merely approximations for general orchard conditions.

Harvesting and packing in a 20-acre orchard of representative varieties and various ages on hilly land in Ohio cost 18 cents per bushel. Packages, trucking, and storage for the season cost 24 cents per bushel over a 13-year period. Over a period of 5 years, on a lot of 15,000 bushels from an orchard in the same state, it has cost 10.33 cents for picking alone; 3.48 cents per bushel for hauling apples from orchard to the packing house; 5.92 cents for grading and packing the fruit, exclusive of wages of the foreman of the crew. In the Hudson Velley of New York State, for the crop of 1931 it cost 217 growers who operated 509 apple orchards an average of 10 cents a bushel for picking, 7 cents a bushel for packing, and 8 cents a bushel for hauling and marketing. The price of labor for these 509 orchards varied, some growers paying by the day and some by the box. See also Table 43, page 354, and Table 45, page 427.

4. Storing. Storage plays an important part in the fruit world. Were it not for the development of storage and refrigeration systems whereby fruit may be held for extended periods, the different varieties and kinds would be available only through their periods of production. Movement to market would of necessity take place immediately. Storage extends the season and tends to make the supply uniform throughout the season. It stabilizes both supply and prices. This has its advantages from both the producing and the consuming standpoints.

Factors and Procedure:

(*a*) Determining advisability of storing.
(*b*) Forms of storage.
(*c*) Determining whether to buy storage space or to build.
(*d*) Factors for successful common storage.
(*e*) Determining the type of common storage to build.
(*f*) Operating the storage plant.
(*g*) Picking and packing fruit for storage.

(*a*) *Determining Advisability of Storing.* It is evident that some fruit must be stored each year if prices are to be satisfactory. It cannot all be forced on the market in the fall months.

TABLE 5

Apples: Cold Storage Holdings by Month in Terms of Barrels, Boxes and Bushels 1934–35 — 1938–39

Barrels

Season	Oct. 1	Nov. 1	Dec. 1	Jan. 1	Feb. 1	Mar. 1	Apr. 1	May 1	June 1
	1000 barrels	*1000 barrels*	*1000 barrels*	*1000 barrels*	*1000 barrels*	*1000 barrels*	*1000 barrels*	*1000 barrels*	*1000 barrels*
1934–35	209	872	797	678	506	338	172	68	17
1935–36	320	979	950	789	637	435	205	86	22
1936–37	66	313	307	233	176	121	42	15	3
1937–38	135	501	483	411	322	218	83	32	13
1938–39	177	383	320	221	149	81	26	9	5

Bushel Baskets and Eastern Boxes

1934–35	3,370	10,858	10,555	8,922	6,937	5,084	3,225	1,557	468
1935–36	3,307	12,607	12,814	11,489	9,820	7,250	4,640	2,146	857
1936–37	3,904	11,763	11,641	9,795	7,631	5,021	2,654	1,226	479
1937–38	5,421	17,653	18,727	16,819	14,356	10,917	6,983	3,365	1,134
1938–39	6,754	16,234	15,051	12,866	10,006	7,200	4,089	2,082	756

Boxes

Season	Oct. 1	Nov. 1	Dec. 1	Jan. 1	Feb. 1	Mar. 1	Apr. 1	May 1	June 1
	1000 boxes	*1000 boxes*	*1000 boxes*	*1000 boxes*	*1000 boxes*	*1000 boxes*	*1000 boxes*	*1000 boxes*	*1000 boxes*
1934–35	8,279	17,750	18,037	15,713	12,329	7,839	4,185	1,804	562
1935–36	3,263	15,283	17,390	15,201	12,944	9,374	6,052	2,946	1,074
1936–37	3,339	12,743	13,924	11,863	9,201	6,809	4,580	2,258	899
1937–38	1,612	12,264	15,878	13,952	10,958	7,969	4,807	2,318	796
1938–39	1,394	12,887	14,804	13,037	10,520	7,959	4,972	2,598	896

Total

	1000 bushels	*1000 bushels*	*1000 bushels*	*1000 bushels*	*1000 bushels*	*1000 bushels*	*1000 bushels*	*1000 bushels*	*1000 bushels*
1934–35	12,276	31,224	30,983	26,670	20,784	13,938	7,926	3,564	1,080
1935–36	7,530	30,828	33,054	29,058	24,675	17,928	11,307	5,349	1,997
1936–37	7,441	25,445	26,486	22,357	17,360	12,193	7,360	3,529	1,387
1937–38	7,438	31,420	36,054	32,004	26,280	19,540	12,039	5,779	1,969
1938–39	8,679	30,270	30,815	26,566	20,973	15,402	9,192	4,707	1,667
Average	8,673	29,838	31,479	27,331	20,015	15,801	9,565	4,586	1,620

Table 5 indicates that apples are available from cold storage throughout nine months of the year and gives an idea of the enormous extent of the storage business. November to March is the period of heaviest holdings.

The normal market for fresh apples from commercial fruit sections (the "commercial crop" of the United States Department of Agriculture) in the United States is about 75 million bushels. In other words, this quantity may be marketed over the season at fairly satisfactory prices. Under normal conditions export markets take about 10 million bushels (not in war times when major European powers are involved). Thus there is ordinarily a satisfactory outlet in prospect for about 85 million bushels. When the crop exceeds this figure and prices in the fall are low, it may be well to remember that they may be lower later with storage costs added to the grower's investment.

Many growers make a practice of storing a certain proportion of their crops each year. They do this on the assumption that it is quite as risky to store the entire crop as it is to sell all of it at harvest time, that a combination of the two procedures gives stability to the situation. On the whole, this is probably sound reasoning. Two exceptions to it may be made: first, that the financial pressure may be so great as to compel disposal of the crop at a given time; and, second, that whenever prices are satisfactory it is a good time to sell, regardless of other factors.

Conditions in a single section do not provide sufficient data on which to base action. Study the national situation from the best sources obtainable, including the reports of the United States Bureau of Agricultural Economics as to volume of crop and storage holdings. Study also the general economic situation, including probable foreign demand.

Studies made in New York State which are probably applicable elsewhere indicate that the two factors which exercise the greatest influence on the farm price of apples are (1) the purchasing power of consumers and (2) the production of apples in Eastern United States. Therefore, the index of factory payrolls issued by the United States Department of Commerce and the estimates of the Crop Reporting Board should be watched.

The volume of citrus fruit production seems to have much less influence than has been claimed.

It is evident that only the best grades of fruit represent good storage risks under normal conditions.

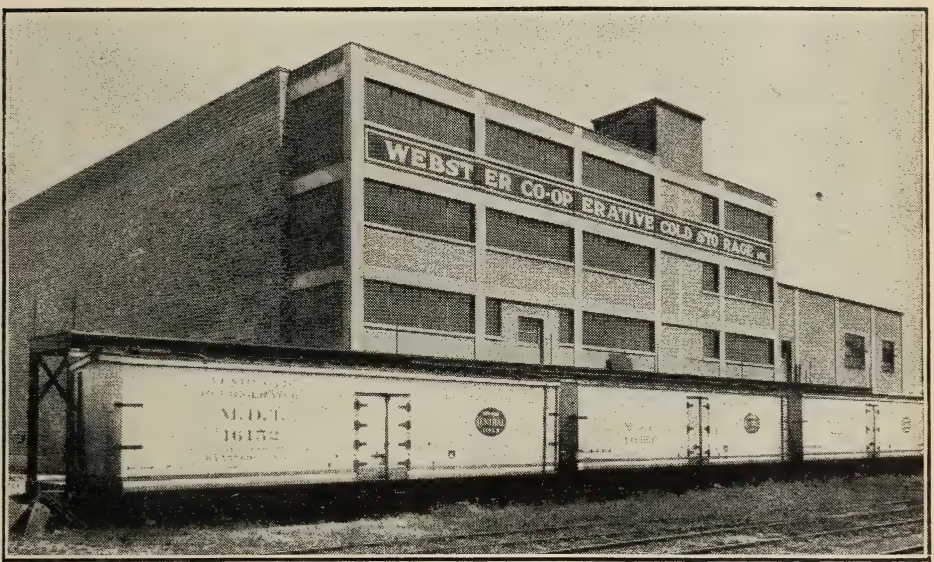
(*b*) *Forms of Storage.* The simplest form of storage is that used by every farmer and by many a townsman, the family cellar. The special common storage cellar or house is a step further. Beyond this point are systems of cold storage through the use of ice or by means of mechanical and electrical refrigeration.

Common storage answers a universal need. For its effectiveness it depends upon the control of the natural factors of temperature, ventilation, and humidity. From the commercial standpoint common storage is of importance in the northern half of the United States where natural temperatures range low enough to make it feasible. In much of the Canadian apple belt and in some sections of the United States, the weather is sharply cool, especially at night, before the fruit is ready to pick.

"Cold" storage, as it is termed, is provided through the use of ice or ice and salt, or by a mechanical process which depends on the compression followed by the expansion of gas or vapor. As gas expands it takes up heat from its surroundings, lowering the temperature of a brine pumped through pipes to the storage room. The material, having expanded into its gaseous form, is condensed and returned to the compressor to be used over again. Another method known as the absorption system but not differing in final results is also used. Ammonia gas is the material commonly employed.

Very low temperatures are secured by mechanical refrigeration. Delicate and intricate devices control the temperature and humidity relations. A detailed discussion of cold storage cannot be included here, but adequate references are provided in the bibliography for those seeking further information.

Cold-storage plants form a very important link in our marketing machinery. They are located both in large producing centers and at consuming markets. Box apples are shipped East and held in them until put on the market. These plants run from 40,000 to 50,000 barrels capacity, or more.



(*N. Y. C. R. R. Co.*)

FIG. 30. A modern cold-storage plant in a producing section, with refrigerator cars on the switch for loading.

A storage plant at Winchester, Va., said to be the largest in the world, has a capacity of 300,000 barrels.

Some growers have cold-storage facilities of their own sufficient to meet their needs as indicated under (*c*).

(*c*) *Determining Whether to Buy Storage Space or to Build.* In many sections common storage, if properly constructed and operated, will care for the crop until it can be sent to market. Some commercial common storage houses are found which will rent space, but they are the exception. As a rule, the grower must provide his own.

Ordinarily the grower cannot have a private cold-storage plant because machinery and equipment are expensive and the size of the business will not warrant the outlay. The construction costs run from 75 cents to $4.00 per bushel capacity, for plants including buildings and equipment, with higher figures in a few cases. The commercial storage charge is by the month or by the season, prices varying with general conditions but approaching 30 cents for the first month for barrels, and 10 to 15 cents per month thereafter, or about 55 to 65 cents for the season to April 1. The charges at the terminals of large cities are usually greater. Rates on boxes are from 15 to 20 cents and on bushel baskets about 25 cents for the season. Fruit may be held later than April 1 at a small additional charge.

Products other than apples are also stored in these houses. Packing rooms are commonly provided in conjunction with storages at producing points, and some such plants are cooperatively owned by growers in the sections tributary to these shipping points.

Growers near markets and those operating roadside stands on a large scale are developing small cold-storage plants of their own, especially in Eastern New York, New Jersey, Pennsylvania, and other Northeastern states. These plants hold from 10,000 to 50,000 bushels. They make possible a continuous supply of high-grade fruit in excellent condition, beginning with the early fruits and extending through the apple season. The fruit is often stored in open packages, as crates or boxes, to avoid pressing. This makes an excellent way to handle the tender dessert varieties.

The plants may be used to store the fruit at harvest, packing it out after picking is completed. Sometimes old buildings are remodeled. Building and equipment costs have run from 65 to 85 cents or more per bushel; operating costs, from 10 to 12 cents from September 1 to April 1. Volume makes a great difference in these costs. Advice should be obtained from competent refrigeration engineers as to plans and equipment.

Under ordinary circumstances, if cold-storage space is available to the grower, it is probable that he might better rent his requirements than construct his own plant. With his own plant some of his costs go on every year, whether he

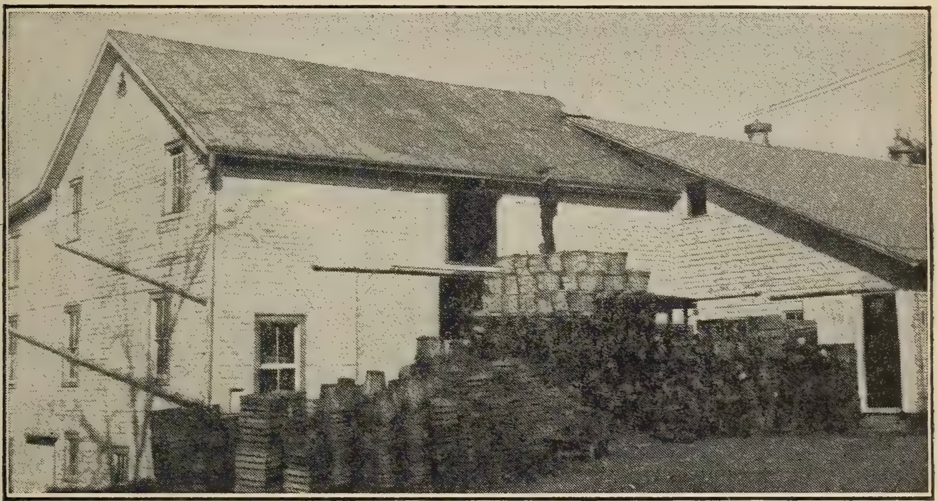


FIG. 31. This is a grower-owned packing house and cold storage in the Hudson Valley Section of New York. The wing at the left is the packing house, remodeled from a farm building. More light would be desirable. At the right and connected with the packing house is the cold storage with a capacity of 10,800 bushels. The storage cost is about $1.00 per bushel, not including some of the owner's labor, of which there is no record. Operating costs average 13 to 15 cents per bushel for a period extending from about Sept. 1 to June 1. Apples are put in the storage when picked and are packed out at the grower's convenience. Much of the fruit is sold at the door and hauled by motor truck.

uses the space or not. He may, of course, send his crop to the terminal market storages, but it is questionable whether all his holdings should be tied up at definite consuming points, with their higher costs.

(*d*) *Factors for Successful Common Storage.* Ventilation, humidity, and temperature are the three factors of most importance in keeping the fruit. Of these, ventilation appears to be of major importance. The air must change rapidly if the fruit is to keep well. For this reason as well as because they are convenient to handle, and rigid enough to protect the fruit, slat crates and lug boxes have been found to be very satisfactory containers.

The reason that artificial cold storages are operated successfully without ventilation is that the temperature is reduced so low that life activities in the fruit are practically at a standstill.

The humidity, or the moisture content of the air, should be high to prevent wilting and shrinking. It should range from 85 to 95 percent. It can be determined by means of the hygrometer. Earth floors, or concrete floors sprinkled with water, aid materially in maintaining proper humidity.

The uniformity of the temperature seems more important in common storage than the exact thermometer reading. With good ventilation and the proper humidity, a common storage temperature between 40° and 50° F., provided the temperature does not fluctuate violently, has been found to keep apples in good condition for comparatively long periods.

(*e*) *Determining the Type of Common Storage to Build.* The storage may be above or below ground. The type in most common use thus far has been the cellar or below-ground storage. The assumption has been that temperature was the main factor to control and that the danger of freezing would be slight in a cellar storage. It is now recognized that ventilation is of great importance in the common storage where the temperature is not low enough to check life processes of the fruit. It can probably be provided more satisfactorily and in a more dependable form in the above-ground storage. By proper insulation the storage above ground may be protected from freezing. Construction costs do not differ materially between the two types, running usually from 40 to 75 cents per bushel, depending upon the capacity, building materials, and labor costs. Barns and various farm buildings may often be converted into satisfactory storage plants.

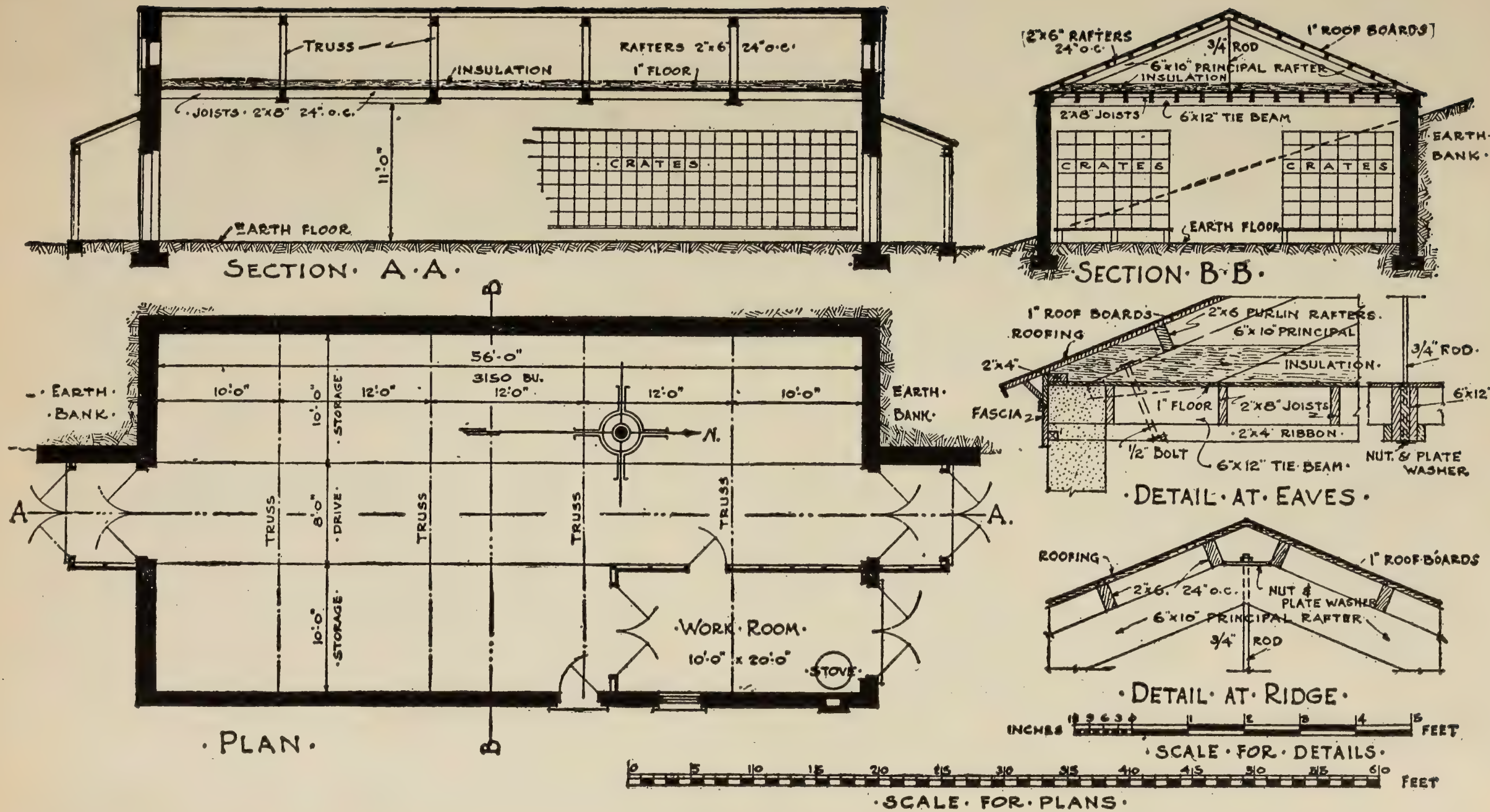


FIG. 32. These plans of a common storage built into a side hill, so that the storage is largely underground, were drawn by the Pennsylvania State College. The construction cost is given as 72 cents per bushel. The capacity may be increased by adding to the length.

Cellar storages are commonly constructed in a bank with access on the exposed ends, or at one side (Fig. 32). The walls may be of stone, concrete, brick, hollow tile, etc. Such walls, especially where exposed, may be further insulated with hair, felt, granulated cork, sawdust, shavings, etc. Drains should be placed at the back of the walls and should have proper outlets.

Ventilation should be provided through large doors, preferably one on each end. It has been found by the Pennsylvania Station that ventilation ducts and outlets are not so efficient as large doors and windows. An earth floor is best, with a false wood rack floor on top, to promote ventilation and care for the humidity requirements. Cross-pieces should not be placed at right angles to the movement of the air under such a floor as they will interfere with circulation. A concrete floor may be used but will often require sprinkling to keep the air sufficiently moist.

Often such a cellar forms the basement of a building, the upper floor of which is used for packing and the storage of packages. The roof construction over the cellar should provide insulation.

A properly insulated common storage above ground should give results as good as or better than a cellar storage (Fig. 33). This is because the former is not influenced by ground temperatures to the extent that the cellar is, and the grower can control conditions better.

Many types of construction and various materials have given satisfaction for storages above ground. Wood construction with proper insulation is both economical and efficient. Of course, it does not reduce the fire hazard as much as other types of construction.

Studding 2 by 6 inches covered with matched siding sheeted with building paper will provide a 6-inch insulation space between the studding. Granulated cork or cork dust is excellent insulating material and is not expensive. For ordinary temperatures, such as are experienced in southern New York

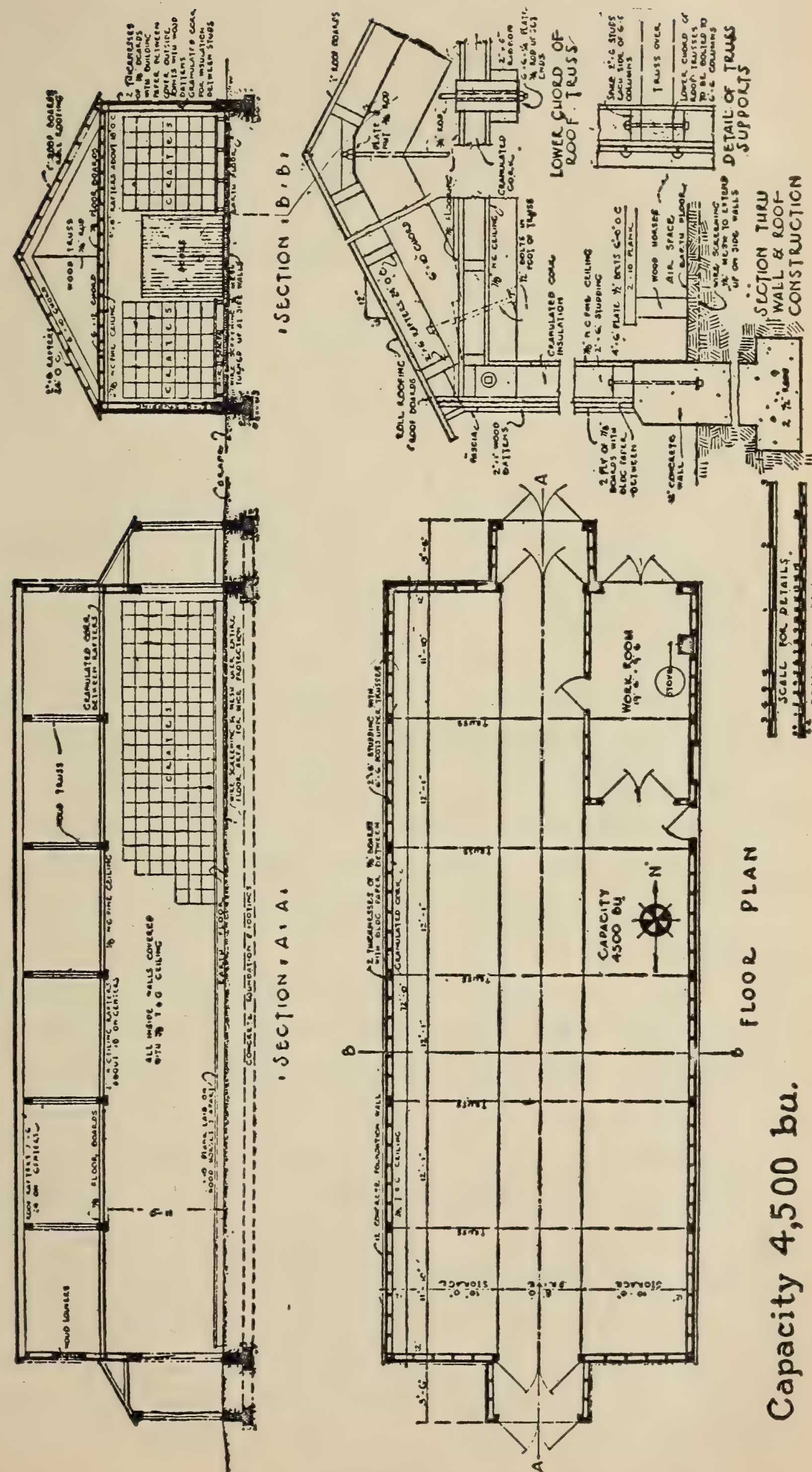


FIG. 33. The plans for this common storage above ground were drawn by the Pennsylvania State College. Construction costs are about the same as for the storage in Fig. 32.

and Pennsylvania, filling the space with this material will provide adequate insulation. The thickness of the insulating material should be increased in more severe climates. Other cheap insulation materials are sawdust and mill shavings. It is essential that the insulation material, of whatever nature, be kept dry.

For insulating purposes the following information from the Engineering Department of Pennsylvania State College is presented. One inch cork board is approximately equal in value to:

1 inch granulated cork.	8 inches dry soil.
1 inch Celotex.	48 inches wet soil.
1 inch insulite or insulex.	12 inches brick.
1⅓ inches sawdust.	12 inches hollow tile.
1⅓ inches shavings.	24 inches concrete.
3¼ inches wood.	30 inches stone.

Brick, stone, hollow tile, concrete, etc., do not insulate sufficiently without interior layers of non-conducting materials. Interlocking tile waterproofed on the inner and outer walls provides good insulation at a moderate cost, as well as protection from fire. Corkboard, wood fiber, hair, asbestos, mineral wool, cinders, and mica are some of the newer insulating materials.

The ceiling should have from 4 to 6 inches of insulation. Frequently it consists of granulated cork spread evenly over the matched boards, but a foot or more of finely broken or well-packed straw is also satisfactory.

An earth floor overlain by a wood floor raised 6 to 8 inches on stringers or concrete sills gives good humidity conditions. Rodents may be controlled by covering the earth floor with wire netting or hardware cloth of ¼-inch mesh.

A concrete driveway should be provided directly through the building so that fruit may be unloaded conveniently at any point. This driveway may be filled with fruit after the rest of the house is full.

Large doors should be provided in each end. Refrigerator doors may be desirable. A vestibule in front of each door will prevent the sun from shining directly into the storage and is important in both types of storage. Movable sills may be placed at the bottom of doorways; they may be raised or taken out when loads are coming in. Windows should have double sash, covered by sealed or battened hinged doors.

Some authorities advise a cold-air intake near floor level, 20 by 30 inches, for each 2500 cubic feet of capacity and warm air outlets in the roof providing 2 square feet of opening for each 2500 cubic feet. Such outlets must be insulated and equipped with closing devices. Two or three outlets would be sufficient for the usual storage.

A packing or work room may be provided in the same building but should be separated from the storage proper.

(*f*) *Operating the Storage Plant.* Fruit brought in while cool is in better condition for storage than that warmed by the sun or stored in the heat of the day. A good plan, where practicable, is to allow it to stand out over night, to be stored in the morning while cool. A small room equipped with mechanical refrigeration is useful in reducing the temperature of the fruit before placing it in the common storage room. Stack the fruit, preferably in slatted crates, leaving a space of 6 to 8 inches between the crates and the outer walls; have corridors wherever needed.

The apple box in common use is a good storage package if slats are nailed on the tops of the boxes to provide some ventilation between them.

Ventilate the storage freely. Leave the doors of either type of storage open whenever the outside temperature is lower than the inside temperature, until the storage temperature is close to freezing. In the cellar storage, ventilation should be provided during the day, even when the weather is warm; the warm air probably will affect the below-ground cellar temperature but slightly because of the cool damp walls and floor, and will provide the much-needed ventilation. Ground temperatures below the frost line are between 50°–60° F. If the humidity is low, sprinkle the floor. This will seldom be necessary except where a concrete floor has been used. The above-ground storage should be closed on warm days, but opened at night.

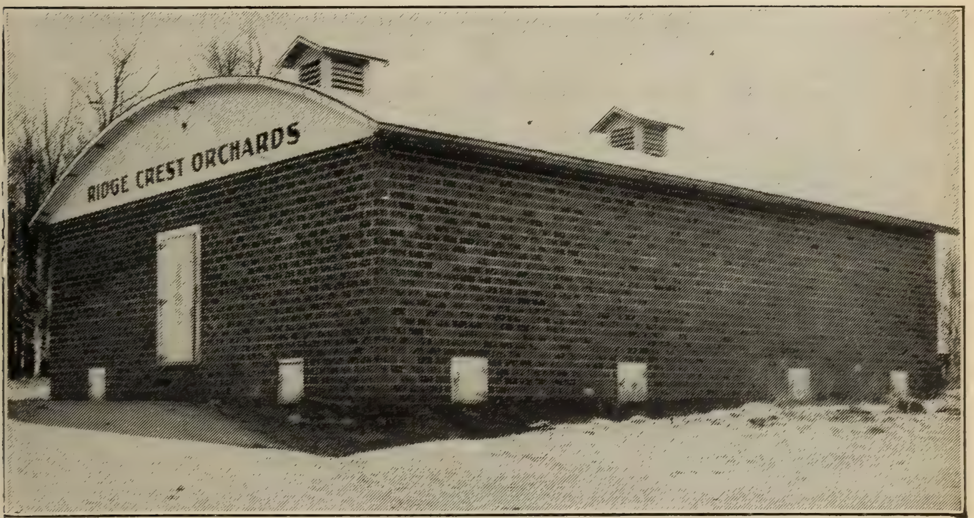
(*Mich. State College*)

Fig. 34. This frame storage was built in 1922 at a cost of $4,000. It is 40 by 60 feet and has a capacity of 10,000 bushels. A grading room extends across the front. The second floor is used as a storage for empty containers. This is one of the few storages in Michigan with a permanent false floor. A 2-inch thickness of hair felt in the walls provides excellent insulation. Note the location of air intakes and outlets.

(*g*) *Picking and Packing Fruit for Storage.* This has already been treated in connection with "Picking the Fruit."

Store only sound, mature fruit. Fruit lacking maturity does not keep well. The chief cause of the development of scald on certain varieties in storage is probably picking at an immature stage. On the other hand, there is danger in some regions with long picking seasons of leaving the fruit until it is too soft. Store only good grades of standard varieties, and do not seek to hold them beyond their natural storage season.

Store immediately after picking. Every day that fruit remains out of storage after it is picked cuts down the length of the time that it can be held in storage. A temperature approaching 30° F. has been found most desirable for apples



(*Mich. State College*)

Fig. 34*A*. This air-cooled Michigan storage, 36 by 50 feet and 13 feet from floor to ceiling, accommodates 8,500 bushels. In the outlet flues are motor-driven fans which can change the air completely seventeen times in an hour. The storage has a gravel floor.

in cold storage. Excellent results have been secured in common storage at 40° to 45° F., the important thing, in addition to ventilation, being to prevent too wide and rapid fluctuation. Apples will withstand temperatures below 32° F. for short periods without damage and are sometimes subjected to lower temperatures before picking in late fall. If frosted, fruit should not be disturbed and the temperature should rise very slowly. Apples frosted on trees in the fall often escape injury if the weather is cloudy as the temperature rises.

Apples are not usually repacked when taken from cold storage. In barreled apples, the face may be examined and any defective apples replaced. If the barrel has become slack, as frequently occurs, a cushion is inserted.

Storage Scald: Rhode Island Greening, Yellow Newton, and some red varieties, including Rome, York Imperial, Stayman Winesap, and Baldwin, often develop a brown skin in storage (Fig. 35). It sometimes appears very rapidly after removing the fruit from cold storage and holding it at room temperature for a few days. It usually appears on the green or uncolored sides of the apples, though it may be found elsewhere. The market value of the fruit is affected and in severe cases is destroyed.

(*N. Y. State College of Agr.*)

Fig. 35. Typical storage scald on Rhode Island Greening.

It is known that no fungus organism is involved. The difficulty seems to be due to the accumulation of gases derived from the volatile oils of the fruit. These exist only in minute quantities, yet under certain conditions they appear to kill the epidermal cells and cause the browning.

In addition to the selection of sound, mature fruit, stored at once after picking, use oil wrappers impregnated with 18 percent of a cheap mineral oil for box apples if the specimens are wrapped individually as in the Western box. For apples packed without wrapping either in boxes or barrels use shredded oil paper, distributing it through the package, using about ½ pound to the bushel. In seasons when it is anticipated that scald will be unusually prevalent, or for varieties that are especially susceptible, ¾ pound may be used. Shreds about ¼ inch wide, and 3 to 5 inches in length, made of a paper that does not pack down, are desirable. The exact quantity of oiled paper used seems less important than to have a bit of the paper in contact with every apple.

Modified Atmosphere Storage. At the close of this chapter under General Information the possibilities of a modified atmosphere storage, particularly for apples and pears, are presented. The term "modified atmosphere" simply means that the proportions of oxygen and carbon dioxide are changed from those existing in the normal atmosphere in such a manner as to reduce life processes of the fruit and extend its period of keeping in a desirable condition. The term "gas storage" is sometimes applied. Considerable work in this field has been done in England. Both the California Experiment Station and the New York State College of Agriculture at Cornell University have conducted investigations in this country and the findings to date are presented. The possibilities in the process, especially for McIntosh apples, as studied at Cornell, and pears, as studied both in England and California, seem very promising.

Developments in this field and their commercial implications should be watched with close attention.

5. Marketing. The grower is in a real sense attacking his marketing problem when he is growing his fruit. The marketing problem is first of all a production problem. Until something is produced that someone wants there can be no marketing problem. Thus the first and the most essential factor is to grow superior fruit. It must then be picked carefully, graded according to rigid standards, and packed in a manner acceptable to the consuming public.

Procedure:

(*a*) Consider ways in which apples may be sold.
(*b*) Consider functions performed in marketing.
(*c*) Study various marketing agencies.
(*d*) Secure shipping point inspection.

(*e*) Load cars properly.
(*f*) Consider market preferences and prices.
(*g*) Consider export markets.

(*a*) *Consider Ways in Which Apples May Be Sold.* Large quantities of apples are sold in some sections to local dealers acting for themselves, or as agents with outside connections. In some sections much of the fruit is packed by the growers and sold at the shipping point (f.o.b.) either to local dealers or agencies outside. F.o.b. sales, with shipping-point inspection, as described later, are decidedly on the increase in most sections.

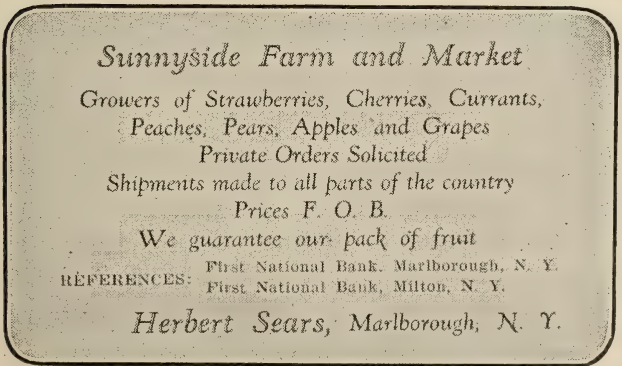
In other sections the fruit is packed by the grower and consigned to agents at the point of consumption, who sell the shipment on commission.

The simplest and most direct procedure is found where the grower deals with the retail grocer in a nearby town or where he works up a direct-to-the-consumer trade. There is opportunity in every section for a few growers to supply their communities in this way. Up to the saturation point for the community, better returns often prevail than on the general market, even considering the greater amount of time frequently spent by the grower in marketing his product.

Roadside or wayside stands and markets have developed with the automobile and good roads. Unsatisfactory prices at terminal and wholesale markets in recent years and the necessity for the grower to retain as much of the consumer's dollar as possible have hastened this development. The proportion of the crop handled through these channels is small, but in favorable locations, and with the opportunity to operate the stands by members of the family, they have presented a favorable marketing opportunity for many growers.

Certain factors governing the success of roadside markets are beginning to emerge. Studies made of 316 such markets during the three-year period 1931-33 and of 153 markets in 1937 by the New York State College of Agriculture indicate

FIG. 36. (*a*) An attractive stand on a main highway in New York. An awning may be attached to the projecting bars. This stand is operated by the grower who handles only his own products. (*b*) A Maryland roadside stand, selling direct to the consumer.



Sunnyside Farm and Market

Growers of Strawberries, Cherries, Currants, Peaches, Pears, Apples and Grapes

Private Orders Solicited

Shipments made to all parts of the country

Prices F. O. B.

We guarantee our pack of fruit

REFERENCES: First National Bank, Marlborough, N. Y.
First National Bank, Milton, N. Y.

Herbert Sears, *Marlborough, N. Y.*

FIG. 37. The business card of the grower whose stand is shown in Fig. 36(*a*).

that the following conditions are either essential or highly desirable.

In order to secure a large number of customers, it is necessary to locate near a large village or city on a road over which many consumers pass daily. The possibility of securing a large number of repeat customers is important. Tourists buy little more than they will eat in the car.

A long season of operation is important. A combination of fruits

FIG. 38. This stand is quite attractive. It has good display space and a variety of products. It is too close to the highway, and includes products not grown in the section.

with vegetables and perhaps with other products will lengthen the season of operation.

Regularity of operation helps to build up a repeat trade. A large amount of business is done over the weekend.

The use of lights increases the length of daily operation and enables the grower to sell to many customers who would not come during the day. Water to keep products fresh and as a convenience for motorists is desirable.

A permanent stand is more attractive and should be used whenever the volume of sales and the marketing period justify the investment. However, the grower should not seek to build a store and should keep his overhead investment down.

The general appearance of the stand and its surroundings are important. In the studies mentioned, sales from unpainted stands amounted to $81 per week, from painted stands $128 per week. The stand should be located in a prominent position on a stretch of straight road or on a broad hilltop and have adequate parking facilities on both sides of the road, if possible. Traffic hazards should be avoided. The presence of trees for appearance and shade is a distinct advantage.

A good salesman, neat and courteous, who makes friends readily, is a most important factor in making sales and building up a repeat trade.

(*W. F. Allen Co.*)

Fig. 38*A*. A most uninviting stand. Compare with Figs. 36 and 38.

A good display of fresh produce of high quality is very desirable. The produce should be kept fresh and attractive and free from the appearance of having been sorted over at all times.

Most operators find that prices somewhere between wholesale and retail result in larger sales and greater income. Price tags may help sell produce when the salesmen are busy.

An attractive and distinctive name, easily remembered, with some farm or horticultural or geographical significance, will help.

Plans and estimates for suitable markets are available from various colleges of agriculture.

Recent studies in the Hudson Valley section of New York indicate that the grower may receive a greater net return for tree-run sales when the entire crop is of high quality than from grading and packing in the usual manner—that returns when sold locally may be more satisfactory than when trucked or shipped to New York City. The same situation may be true in sections adjacent to other large centers of population. This is a very important consideration to the grower.

FIG. 39. An attractive stand for the sale of cider, freshly made.

The Public Cold Storage as a Selling Agency. Since the advent of the motor truck, the public cold storage has become a natural meeting place and general center of information for buyers. The storage management now often sells the fruit for the grower without any charge in addition to the normal storage rate. The amount of fruit sold in this manner is substantial; returns to growers have compared favorably in many cases with those from other methods of selling, and the practice is growing. Satisfactory results build business for the storage management and ease the marketing problem for the grower.

The grower sets the figure which he desires to receive for a given lot of fruit and the minimum that he would take for it. He may revise these figures from time to time as market conditions change. The storage management operates within this range, keeping in touch with the grower and seeking the most favorable sale. The management collects from the buyer and makes the return to the grower.

It is evident that this method depends for its success very largely upon the personal attributes and the business judgment of the storage operator.

Collective Selling. The grower may often strengthen his position materially from the marketing standpoint by pooling his efforts with those of others engaged in the same line of business. This brings up the question of the cooperative packing association. Chief among its advantages from the marketing standpoint are:

1. It provides a standardized product. Perhaps 50 growers bring fruit to the packing house, where it is packed by disinterested parties into the proper grades. Though the grades may not be entirely uniform owing to variations in the individual lots of fruit, particularly as to color, they will be much more uniform than if packing is done by individual growers.

2. A sufficient volume of standardized produce is provided to prove an inducement to buyers. Buyers desire a product to conform to certain specifications. They wish to be able to obtain it at need and in sufficient quantities. Repeat orders are the goal of all business. The individual fruit grower, as a rule, cannot supply repeat orders; the cooperative packing association can. For this reason, the ability to supply in carlots, at times needed, the packing association obtains a foothold in the fruit trade world that is denied to an individual, unless he is a very large grower.

3. The association can keep in closer touch with market conditions. It may even have representatives or agents in some of the larger centers. It is thus in a stronger position to market its output intelligently and to make a satisfactory deal with the buyer than the individual grower is.

4. The association can take steps to enlarge and increase its markets that would be prohibitive to the individual grower on account of the cost involved. It can carry on extensive advertising and publicity campaigns.

California oranges are found in every hamlet in the country, put there and kept there through the application of the principles outlined above, absolutely impossible of application by the individual orange grower, perfectly possible for a strong well-organized and well-managed association of growers. Comparison between citrus growing and apple growing is not entirely safe because of the extreme centralization of the citrus-producing areas, making organization comparatively simple, but commercial apple growing is tending toward restriction to well-favored areas of intensive production, and apple growers may learn a great deal in regard to marketing from the orange, lemon, and grapefruit growers.

5. The association may, by pooling orders, often purchase supplies of all kinds needed by its members at a decided saving to the individual. This item has been one of the strong inducements in some places to form such an organization.

A Grower's Organization

The New York and New England Apple Institute is an illustration of what growers acting jointly may do to help themselves. It is a branch of the National Apple Institute incorporated in 1935 as a membership corporation in New York State. It serves New York and New England and cooperates with similar agencies in other sections.

It is a growers' organization, non-profit-making, formed for the purpose of increasing the sale and consumption of native-grown apples, to make the public more apple conscious, and to assist the apple industry in its marketing problems.

The grower members each year elect institute officers from their own number. They engage a paid manager and necessary office assistance. They derive their financial support from a voluntary pledge of 1 cent per bushel of their commercial crop of apples, culls and drops excluded. Growers pay one-third of the estimated amount by October the first of the crop year, the rest from time to time as the crop is sold, making full payment not later than the middle of the following June. Some additional support has also come through contributions by certain state departments, cold storages, and other allied businesses. Much valuable advertising is effected by distributing educational literature to schools and consumers' organizations. Chain stores, independent grocers, super markets, commission men, and wholesalers do a great deal to assist the institute in conducting newspaper and other displays. Monthly confidential bulletins explaining the current activities of the institute are sent to its members. At present the promotion of better grading and packing, the improvement of apple containers, and the publicizing of the health values of apples are receiving chief attention.

Since its beginning only five years ago the institute has accomplished a great deal. Consumer interest and demand have been stimulated; new outlets for apples have been found; apples have been listed for sale cooperatively; varieties have been marketed at their proper season. In the crop year of 1939–40, the institute performed yeoman service in the orderly marketing of a very large crop at prices which, under the conditions, were very good. The institute constitutes a type of service which growers should support in every apple-growing section. It demonstrates that growers are not powerless in the face of adverse marketing conditions, that there is much which they may do for themselves.

Table 6 and Fig. 40 list the unloads of apples in New York City from 1932–1939 inclusive by rail, boat and truck in terms of carloads. Not all the apples unloaded in New York City are consumed there for the city serves as a distributing center to smaller communities in the adjoining territory. The average receipts are 9966 cars, of which shipments by truck now constitute about 60 percent. Of the 6570 cars received by truck in 1939, 5831 cars went to twelve wholesale markets and 739 cars to three farmers' markets.

Motor truck shipments are increasing because growers can load and deliver almost at their option within very narrow time limits. A serious problem is that the individual grower does not know the extent of the truck movements and the supplies available on a given date. Ultimately public au-

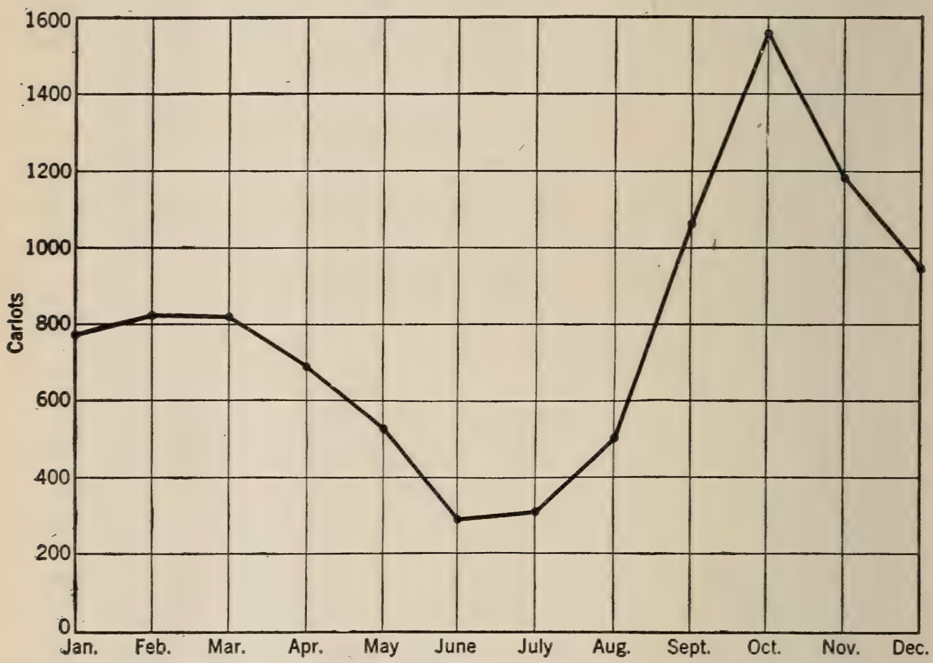


FIG. 40. Carloads of apples unloaded in New York City by months from 1932 to 1939, inclusive—an 8-year average.

thorities will be expected to provide this information through some type of forecasts and reports available to all.

Motor truck shipments to New York City originate for the most part in Connecticut, Delaware, Maryland, Massachusetts, New Jersey, New York, North Carolina, Pennsylvania, and Virginia.

It is probable that development of truck transportation in the New York City area is similar to that taking place in the territories serving other large centers of population.

TABLE 6

APPLES—UNLOADS AT NEW YORK BY RAIL (INCLUDING BOAT) AND TRUCK, 1932–39

Figures given are carlot equivalents.

Year	Rail (including boat)*	Truck	Total
1932	9775	3059	12,834
1933	6511	4179	10,690
1934	5567	4412	9,979
1935	4814	4762	9,576
1936	3791	4667	8,458
1937	4113	4152	8,265
1938	3936	5372	9,308
1939	4047	6570	10,617
Average	5319	4647	9966

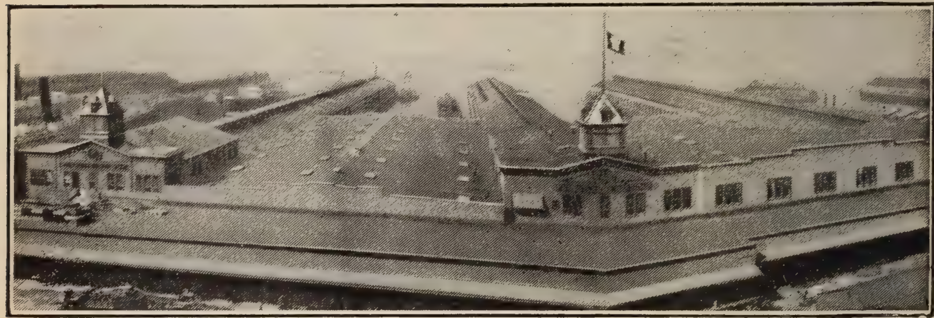
* Boat receipts are insignificant.
Note increase in proportion of truck shipments.
1939 unloads of oranges were 21,646 cars, bananas 11,773 cars, grapefruit 7559 cars.

(b) *Consider Functions Performed in Marketing.* In whatever manner fruit may be sold, the marketing of the crop involves a number of distinct functions. Whether most of the operations are performed by the grower or some other agency, they represent a definite service rendered and entail an unavoidable cost. The operations named below enter into the marketing of the commercial apple crop and must be performed by someone:

(1) Mobilizing or assembling fruit at local shipping point.
(2) Grading, standardizing, and packing.
(3) Transporting, carting, and delivering.
(4) Storing and warehousing.
(5) Disseminating or demobilizing at wholesale terminal and markets.
(6) Financing and assumption of risks.
(7) Final distribution for consumption.

If the grower or his agent does not perform these functions, someone else must do so, and the cost of the service must be deducted from the returns to the grower.

The farther down the line the grower continues control of his product, the greater the possibility of increased financial reward, because each agent seeks to protect himself by a safe



(*Pennsylvania R. R. Co.*)

FIG. 41. Piers of the Penn. R. R. Co. in New York City for handling fruits and vegetables. Cars are ferried on floats holding 10 cars each. The piers have unloading space for 190 cars at a time. Their total capacity is 750 cars, 600 cars being the largest number handled to date. Nights are the periods of chief activity, preparing for the buyers who come early in the morning. Negroes and some Portuguese are employed to unload the cars, since these races appear best able to stand the heavy labor. These men work 12 hours on Sunday nights, and 8 hours per night during the remainder of the week. The railroad provides an inspection service in addition to that available through State and Federal sources. Fifty coopers are commonly employed to repair broken packages; 35 groups of men of 8 men each to unload cars, and 35 tally clerks. Auctions are held in special rooms, beginning about 8:00 A.M., delivery of products occurring immediately thereafter.

margin, but also the greater the risk that the grower runs. Even community or central packing house associations with large outputs usually sell their fruit through a commission house, or broker, indicating that there is a point in the marketing process at which it is desirable for a special agency or organization closely in touch with market affairs to step in and take over responsibility.

(c) *Study Various Marketing Agencies.* At destination the fruit is ordinarily handled by a commission house, selling to a jobber or a large retailer, for 7 to 10 percent of the gross sale, depending upon the size of the transaction. The commission man inspects the fruit on arrival, pays transportation charges, cartage, and storage charges if any, negotiates a sale, collects the money, deducts all charges plus his commission, and makes return to the shipper. Some states maintain lists of bonded and licensed commission merchants for the protection of shippers. It is well to consult such lists before establishing a connection.

The Jobber. The jobber purchases the fruit and resells on his own initiative. He may have a definite outlet in mind when he buys, or he may match his knowledge and experience against the turns of the market. He may gain or lose heavily. The fruit may go through the hands of several jobbers before it is offered for consumption by the retailer.

The Broker. Brokers are intermediary agents between buyers and sellers. They are located in the market centers and as a rule deal only in carlots. The broker seldom has the goods in his possession. On information from the seller concerning the nature and grade of the product, the broker seeks a buyer among the trade. He wires the best terms he can get to the seller for acceptance or rejection. If the terms are accepted, the broker executes a sales contract, the goods are supplied, and he receives his commission (brokerage fee). It requires little in the way of an investment to engage in the brokerage business. It follows therefore that a broker should be selected with great care, and from among those who have established reputations.

Selling by Auction. Thirteen cities in the United States now maintain 14 fruit auctions. They are: Boston, New York City (2), Philadelphia, Baltimore, Pittsburgh, Cincinnati, Cleveland, Detroit, Chicago, Minneapolis, St. Paul, St. Louis, and New Orleans. With the exception of New Orleans, all these cities are in the section east of the Mississippi and north of the Ohio Rivers. This is the area of greatest density of population.

A fruit auction is a place with facilities for displaying the merchandise, where buyers and sellers come together, with an auctioneer to sell the products. It is conveniently located for receipt of goods by ship or rail. It has ample unloading and warehouse facilities, and a selling room for the assembling of those interested in the auction, and where the selling actually takes place. The auctioneer conducts the sale from a high rostrum so that he may see everyone and all may see him. The seller may withdraw his offering under prescribed conditions, but may not bid himself.

The auction house publishes a catalogue giving essential information about the quality and grade of goods, terms of sale, etc. Selling proceeds item by item or line by line. Buyers are usually wholesale grocers, restaurants, chain stores, hotels, or brokers. Small lots may be bid in by hucksters and push-cart men. The usual selling charge is from 2½ to 3½ percent on standard products in quantity. Consignment is not made direct to the auction company, but to a commission agent in the usual way, or to some representative of the shipper. The commission man in such case makes a lower charge, since the auction company does the selling.

Auctions for the most part serve large organizations. They handle an enormous volume in a short period. A carload may be sold in 3 minutes or even less. Few individual growers use auctions, partly at least because they do not have the necessary volume of produce. Only well-known and carefully standardized brands are handled.

The auction method of selling is on the increase. Thus far only foreign fruits, as bananas, the citrus fruits of Florida and California, and the deciduous fruits of the Far West have been sold to any great extent by this method. Other fruit growers nearer the consuming centers have sold in the usual way. However, farm cooperatives are introducing the auction method in some producing sections. Their development should be watched and aided wherever feasible. Auctions are used extensively in Europe.

Retail Agencies. Grocers, delicatessen stores, fruit and vegetable stands, and hucksters sell the fruit to the ultimate consumer. Fancy grocers and fruit stands sell in small quantities, by the piece or in small packages, with a large margin.

The general grocer as a rule handles medium goods in larger quantities with a smaller margin. However, he sells many lots of a few pounds each, entailing considerable handling; the waste and loss are large items and the margin is greater for these reasons than could be justified otherwise.

Hucksters, peddling by pushcarts and otherwise, handle large quantities in the course of the year. They buy and sell anything that gives hope of a profit.

Table 7 indicates what actually happened to a shipment of Virginia apples packed in 50-pound baskets which arrived in Washington Market, New York City, on January 27, 1937.

TABLE 7

History of Shipment of Virginia Apples To Washington Market, New York City, as Compiled by New York City Department of Markets and Works Progress Administration

	Gross Margin	Cartage and Transportation	Net Margin	Percentage of Housewife's Dollar
Retailer charged housewife $2.50	0.85	0.07	0.78	31.2
Jobber charged retailer.... 1.65	0.25	0.07	0.18	7.2
Wholesaler charged jobber. 1.40	0.20	....	0.20	8.0
Shipper received from wholesaler............. 1.20	1.20	0.20	1.00	40.0
Transportation, cartage, handling				13.6
	2.50	0.34	....	100.0

The percentages absorbed by the various agencies disclose that 40 percent of the sum paid by the housewife went to the shipper. The shipper might be the grower, or a local dealer. In the latter case, the grower's percentage would be reduced still further.

It is estimated by the Department of Markets that savings of 25¢ could have been effected had the shipment been sent to the Bronx Terminal Market near the consuming population rather than to downtown New York with its congestion and high marketing costs. The savings, it is argued, would eliminate jobbers' margin and costs, increase the margins of shipper and wholesaler and save the housewife money.

A study of retail outlets for apples and other fruits was made in the New York Metropolitan area in 1938 by the Co-operative Research and Service Division of the United States

TABLE 8

Relative Quantities of Selected Fresh Fruits Sold Annually Per Store by 3009 Retailers of Various Types, New York City, 1937–38

Selected Commodity	Average Quantity Sold Annually per Outlet					
	Fruit and Vegetable Stores	Grocery Stores		Pushcart or Wagon Hucksters	Delicatessen Stores	Meat Markets
		Independent	Chain			
No. of Stores....	1121	479	1219	154	22	14
	1000 lb.	*1000 lb.*	*1000 lb.*	*1000 lb.*	*1000 lb.*	*1000 lb.*
Apples..........	50.8	13.8	7.0	53.9	8.2	19.0
Bananas........	19.4	7.8	6.0	3.3	8.5	9.6
Oranges.........	59.4	21.2	26.2	22.4	16.5	22.4
Grapefruit.......	28.9	10.1	10.7	9.4	8.7	8.6
Pears...........	15.5	3.7	4.2	15.2	2.0	4.7
Total fresh fruit	174.0	56.6	54.1	104.2	43.9	64.3

Farm Credit Administration and the New York State College of Agriculture. The report of the study, which is to be continued, is preliminary in nature, but some of the findings to date are worthy of note.

Fruit and vegetable stands are the most important type of retail outlet for fruits, but pushcart or wagon hucksters lead for apples. See Table 8.

The relationship of the quantity of apples sold, both Eastern and Western, to the annual sales of all fruits and vegetables and to total sales of all commodities by 370 independent retail grocers is set forth in Table 9. In stores doing a business of $30,000 or less annually, fruits and vegetables account for about one-third the total sales.

Fruit and vegetable stands sell fruit and vegetables almost exclusively. Table 10 classifies 976 such stands on the basis of gross sales and the quantities of Eastern and Western apples sold. In general about ⅓ of the total quantity of apples sold are Western apples.

It is usually considered that the size of the family income is the chief factor in determining the consumption of fruits. This is doubtless true when purchasers are free from the influence of sales-promotion activities. Table 11 does indicate that there is a relationship between family income as measured by rentals charged in the area in which the retail outlet is located and the sales of apples and other fruits. Note that sales of all fruits by independent grocers increased rapidly as incomes increased, but that the pushcart and huckster sales were heaviest in the low-income areas. When the high-income groups buy apples from pushcarts, they take the Western apples.

There appear to be some preferences on the basis of nationality in the purchase of apples. Stores catering predominantly to Jewish trade constituted 25 percent of the retail outlets but sold 37 percent of the apples and 35 percent of six other fruits. Italian customers predominating in 15 percent of the outlets purchased 7 percent of the apples, Germans 5 percent and 4 percent respectively.

TABLE 9

RELATION OF APPLE SALES TO SALES OF FRUITS AND VEGETABLES AND TO SALES OF ALL COMMODITIES, AS REPORTED BY 370 INDEPENDENT RETAIL GROCERS, NEW YORK CITY, 1937–38

Annual Gross Sales of All Commodities per Outlet	Stores Reporting	Annual Sales per Outlet		Quantity of Apples Sold		
		All Commodities	Fruits and Vegetables	Eastern	Western	Total
	Number	*Dollars*	*Dollars*	*1000 lb.*	*1000 lb.*	*1000 lb.*
Less than $ 5,000	39	3,500	1,272	3.0	2.6	5.6
$ 5,000 – $ 9,999	57	7,437	2,691	4.0	3.1	7.1
$10,000 – $19,999	81	14,541	5,742	7.1	4.8	11.9
$20,000 – $29,999	64	24,712	8,053	8.8	5.4	14.2
$30,000 – $49,999	67	38,893	9,804	10.4	7.0	17.4
$50,000 – or more	62	89,194	23,294	17.1	10.9	28.0

TABLE 10

RELATION OF APPLE SALES TO GROSS SALES OF FRUITS AND VEGETABLES AND OF ALL COMMODITIES, AS REPORTED BY 976 INDEPENDENT FRUIT AND VEGETABLE STANDS, NEW YORK CITY, 1937–38

Annual Gross Sales of All Commodities per Fruit Stand	Stands Reporting	Quantity of Apples Sold		
		Eastern	Western	Total
		1000 lb.	*1000 lb.*	*1000 lb.*
Less than $ 5,000	116	6.4	4.3	10.7
$ 5,000 – $ 9,999	222	15.7	7.1	22.9
$10,000 – $19,999	329	29.3	11.4	40.7
$20,000 – $29,999	147	40.8	18.2	59.0
$30,000 – $49,999	93	68.2	32.9	101.0
$50,000 – or more	69	93.0	49.8	142.7

TABLE 11

FAMILY INCOME AND ANNUAL SALES OF EASTERN AND WESTERN APPLES, PER RETAIL OUTLET, AS REPORTED BY RETAIL OUTLETS OF THREE TYPES, NEW YORK CITY, 1937–38

Income Class Based on Rentals*	Outlets Reporting	Average Quantity Sold per Outlet			
		Apples			Total for 7 Fruits†
		Eastern	Western	Total	
	Number	*1000 lb.*	*1000 lb.*	*1000 lb.*	*1000 lb.*
479 independent retail grocers:					
$20 – $34	136	4.2	3.6	7.8	31.5
$35 – $49	137	7.5	5.2	12.7	52.2
$50 – $64	82	10.2	5.6	15.8	68.4
$65 – or more	124	11.9	8.2	20.1	106.8
1121 independent stands:					
$20 – $34	202	19.4	15.1	34.5	118.7
$35 – $49	314	43.9	15.3	59.2	212.4
$50 – $64	315	35.0	16.6	51.6	200.9
$65 – or more	290	33.4	18.8	52.2	229.1
154 pushcarts or wagon peddlers:					
$20 – $34	101	41.7	11.2	52.9	113.5
$35 – $49	50	41.2	16.5	57.7	137.3
$50 – $64	2	1.9	35.2	37.1	250.1
$65 – or more	1	....	13.7	13.7	96.4

* Income class based on average rental of census tract in which store is located, as shown by United States Census of 1930.

† Includes apples, as well as fruits listed.

The "margins" taken by city agencies in selling fruit have long concerned growers. It is to the advantage of growers that these margins be sufficient to encourage retailers to push the product and low enough to create volume sales and maintain a favorable competitive position with other products.

Table 12 shows that more than half the retail agencies reported margins of less than 30 percent and 6 out of 10 pushcart and wagon hucksters had margins of less than 20 percent.

TABLE 12

VARIATIONS IN GROSS RETAIL MARGINS ON APPLES, BY TYPE OF RETAIL OUTLET, AS REPORTED BY INDEPENDENT RETAILERS, NEW YORK CITY, 1937–38

Range in Average Gross Margin (percent)*	Total Outlets Reporting	Proportion of Retail Outlets Reporting					Total for All Outlets
		Fruit and Vegetable Stands	Independent Grocery Stores	Pushcart or Wagon Hucksters	Delicatessen Stores	Meat Markets	
	Number	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Less than 15	109	3	5	41	7	..	7
15 – 19	147	8	8	20	..	11	9
20 – 24	255	16	14	20	14	22	16
25 – 29	389	25	27	11	36	11	24
30 – 34	156	11	9	3	14	..	10
35 – 39	183	12	13	1	22	34	12
40 – 49	119	9	7	1	7	..	7
50 – 74	212	14	15	3	..	22	13
75 – 99	13	1	1	..	..	..	1
100 – or more	10	1	1	..	..	..	1

* Gross margin — difference between price paid for commodity and the retail selling price; for example, if a bushel of apples were bought for $1.00 and sold for $1.35, the gross margin was 35 cents, or 35 percent.

As to the size or unit of sale the report makes the following statement:

Practically all the leading fruits were purchased by consumers in extremely small quantities. In 1790 independent retail outlets in New York City, sales of 38 percent of the Eastern apples were in quantities of 3-pound lots, 33 percent in 2-pound lots, and 12 percent in 1-pound lots, making a total of 83 percent in lots of 3 pounds or less. Sales of an additional 7 percent were in 4-pound lots, and 3 percent in 5-pound lots. Sales of Western apples were mostly by number or by the pound. That is, sales of 35 percent were in 3-pound lots or less, and 31 percent in units of 4 apples or less. Similar variations were observed among sales of all the leading fruits. The variations in size and type of retail sales units seriously restrict the field for consumer-size packages.

The spoilage factor influences both the retailer's margin and the size of individual sales. The larger the volume of apples handled, the lower the percentage of spoilage, presumably because the retailer feels that the matter is of sufficient importance to engage his attention, insuring better care, and because of a more rapid turnover. The grower should keep in mind that no one can make the fruit any better than it was when it left his hands. Spoilage, or the certainty of it, often begins, not in the city, but in the orchard, on the truck and in the packing house.

TABLE 13

SPOILAGE AS RELATED TO VOLUME OF APPLES HANDLED AS REPORTED BY VARIOUS TYPES OF INDEPENDENT RETAILERS IN NEW YORK CITY, 1937–38

Quantity handled annually	Percentage of Spoilage			
	Eastern Apples		Western Apples	
	Summer	*Winter*	*Summer*	*Winter*
Less than 50 bushels....	13	8.1	10.9	9.1
More than 500 bushels....	6	...	6.4	...
More than 2500 bushels....	...	5.8	...	4.3

One reason why apples and other deciduous fruits have had hard going in competition with citrus fruit and bananas lies perhaps in the disclosure of the study that, of the fruit and vegetable stands, 96 percent had oranges, 71 percent had grapefruit, and 84 percent had bananas on sale every week in the year against 13 percent for Western apples and about 6 percent for Eastern apples. Of the grocery stores, 28 percent carried Eastern apples and 11 percent Western apples throughout the year. Forty-seven percent of the hucksters carried oranges the year round, but only 5 percent carried apples.

If modified atmosphere storage or some other device will make really fine apples as available as oranges everywhere all the time, this may make a tremendous difference in the present apple-orange relationship.

TABLE 14

SOURCE OF SUPPLY OF EASTERN AND WESTERN APPLES, AS REPORTED BY INDEPENDENT RETAILERS, NEW YORK CITY, 1937–38*

Source of Supply	Proportion Purchased from Each Source by						Volume Handled
	Fruit and Vegetable Stands	Independent Grocers	Pushcart or Wagon Hucksters	Delicatessens	Meat Markets	All Stores	
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Bushels*
Eastern apples:							
Wholesaler or jobber	89.8	96.2	90.7	100.0	95.5	90.5	920,318
Farmer at market..	7.0	2.5	0.4	.....	4.5	5.7	58,429
Fruit auction......	1.9	...	1.2	.....	....	1.6	16,552
Farmer at farm....	1.0	...	5.4	.....	....	1.5	15,390
Wagon peddler or huckster........	†	0.9	2.3	.....	....	0.4	3,838
Farmer at store....	0.3	0.4	...	.....	....	0.3	2,902
Total.........	100.0	100.0	100.0	100.0	100.0	100.0	1,017,429
							Boxes
Western apples:							
Wholesaler or jobber	82.7	98.8	93.6	98.5	100.0	85.6	456,620
Fruit auction......	17.2	0.6	3.7	....	.....	14.0	74,467
Wagon peddler or huckster	†	0.6	2.7	1.5	.....	0.3	1,690
Trucker...........	0.1	...	...	...	.....	0.1	410
Total.........	100.0	100.0	100.0	100.0	100.0	100.0	533,187

* Of the 1790 independent retailers, 91 did not handle Eastern apples, and 98 did not handle Western apples.

† Less than 0.1 percent.

Table 14 is interesting as indicating the sources from which independent retailers secure their apple supplies. From 85 to 90 percent of all apples are obtained from jobbers, but 14 percent of Western apples come through the auction process. Fruit and vegetable stands secure 7 percent of their Eastern apples direct from the growers.

TABLE 15

GRADES OF EASTERN APPLES SOLD, AS REPORTED BY 1699 INDEPENDENT RETAILERS, NEW YORK CITY, 1937–38*

Grade Reported Sold	Retailers Reporting Sale of Grade	
	Number	Percentage of Total
No. 1	302	18
Best	249	15
First quality or first grade	197	12
No. 2	119	7
Extra fancy	102	6
Grade A	83	5
U. S. No. 1	79	5
Seconds	75	4
Ungraded	70	4
Fancy	67	4
Named varieties	39	2
Top grade	31	2
Unclassified	22	1
Cheaper or lower grades	22	1
Good	20	1
Medium	15	1
Others †	..	..

* Ninety-one (or 5 percent) of the 1790 retailers surveyed did not handle Eastern apples.

† Fifteen other grades were mentioned, but no one of them was reported by 1 percent of the retailers.

There is great confusion as to grades and grade terms or at least a widespread use of miscellaneous terms (Tables 15 and 16). However, the retail growers know good apples, and it will be noted that they preponderantly prefer the better grades. Few handle "seconds," "ungraded," "medium," etc., apples from any section.

TABLE 16

GRADES OF WESTERN APPLES SOLD, AS REPORTED BY 1692 INDEPENDENT RETAILERS, NEW YORK CITY, 1937–38*

Grade Reported Sold	Retailers Reporting Sale of Grade	
	Number	Percentage of Total
Extra fancy	306	18
Best	243	14
First quality or first grade	184	11
Fancy	174	10
No. 1	168	10
Grade A	73	4
Second grade	55	3
Named varieties	41	2
U. S. No. 1	27	2
No. 2	27	2
Top grade	26	2
Medium	24	1
Good grade	22	1
Ungraded	17	1
Cheaper or lower grade	14	1
B	10	1
Others †		

* Ninety-eight (or 5 percent) of the 1790 retailers surveyed did not handle Western apples.

† Eleven other grades were mentioned, but no one of them was reported by 1 percent of the retailers.

TABLE 17

Varieties of Eastern Apples Reported Sold by 1699 Independent Retailers, New York City, 1937–38*

Variety	Retailers Reporting Sale of Variety	
	Number	Percentage of Total
McIntosh	1425	84
Greening	1124	66
Baldwin	718	42
York	381	22
Northern Spy	336	20
Delicious	143	8
Rome Beauty	120	7
Wealthy	115	7
Cortland	104	6
Wolf River	93	5
Duchess	58	3
Winesap	42	2
Pippin	32	2
Jonathan	25	1
Williams Red	22	1
Spitzenburg	18	1
Ben Davis	17	1
Golden Delicious	15	1
Gravenstein	14	1
Stark	14	1
"Cooking"	13	1
Coddling	9	1
King	9	1
Others †		

* Ninety-one (or 5 percent) of the 1790 retailers included in this survey did not handle Eastern apples.

† Twenty other varieties were reported as sold, but no one of them was mentioned by 1 percent of the retailers.

As to varieties, though many are handled, only a few are important or really desired. Tables 17 and 18 indicate the situation and contrast both the demand for identical varieties from Eastern and Western sections and, what is more important, the relative standing of varieties in terms of demand. Michigan, Ohio, and Shenandoah-Cumberland apples are included in the Eastern list with those of the Northeastern States. It is also evident that retail agencies, to say nothing of con-

TABLE 18

VARIETIES OF WESTERN APPLES REPORTED SOLD BY 1692 INDEPENDENT RETAILERS, NEW YORK CITY, 1937–38*

Variety	Retailers Reporting Sale of Variety	
	Number	Percentage of Total
Delicious	1546	91
Winesap	694	41
Pippin	356	21
Rome Beauty	277	16
Spitzenburg	219	13
Jonathan	189	11
Newtown	96	6
Golden Delicious	85	5
Gravenstein	74	4
McIntosh	46	3
York	17	1
Northern Spy	16	1
Winter Banana	15	1
Baldwin	14	1
Northwestern Greening	11	1
Others †		

* Ninety-eight (or 5 percent) of the 1790 retailers included in this survey did not handle Western apples.

† Nine other varieties were reported as sold, but no one of them was mentioned by 1 percent of the retailers.

sumers, are still unfamiliar with many varieties. Coddling is an old variety—probably not a bushel reaches the New York market; Pippin in the Western list is probably Newtown; McIntosh, Northern Spy, and Baldwin do not belong in the Western list; Stayman Winesap, a variety of substantial importance, appears on neither list. It may be included with Winesap, a distinct variety.

Chain-store systems are strong promoters of the sale of apples, giving a large amount of publicity consistently throughout the year to the effort. They are cooperating well with growers' organizations. In New York City in 1937–38, five chains sold 345,000 bushels of apples, of which 75 percent were from Eastern growing sections. Table 19 lists the price per pound by months of apple varieties handled by these chains. The figures following the variety names indicate the number of apples in the package. Prices vary from year to year; the relationships between varieties are of interest. Chain stores know their varieties, because fruits are usually purchased in large quantities by experienced buyers.

In 1938, the United States Department of Labor made a survey of the incomes of 14,266 families in New York City. It found that

24.2%	had a family income of less than	$1000
14.9%	" " " " "	$1000 — $1499
18.4%	" " " " "	$1500 — $1999
14.6%	" " " " "	$2000 — $2499
10.2%	" " " " "	$2500 — $2999
12.6%	" " " " "	$3000 — $4999
5.1%	" " " " "	$5000 and more

Granted that this situation may not be normal, owing to general conditions, it still is evident that the bulk of city families have very modest incomes, that they must buy with care, and that it is a major concern of the grower that distributing

TABLE 19

COMPARISON OF AVERAGE RETAIL PRICES PER POUND FOR SELECTED FRUITS IN CHAIN GROCERY STORES, NEW YORK CITY, 1937–38

Variety of Apple	1937						1938					
	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
	cents per pound						cents per pound					
Eastern Delicious—loose	....	....	4.9	4.4	4.8	5.0	5.0	5.0	5.0	4.8	4.8	5.7
Eastern McIntosh—112	....	....	....	7.1	6.4	6.4	6.4	6.6	6.6	6.4	...	...
Eastern McIntosh—loose	....	....	4.6	5.0	5.6	5.8	5.3	4.8	4.9	5.2	5.3	5.5
Eastern Rome—loose	....	....	....	....	....	...	...	3.3	2.7	3.3	3.3	4.7
Eastern York—loose	....	....	....	2.5	3.8	4.2	3.5	3.5	3.2	3.3	...	...
Eastern Greening—loose	5.9	4.7	4.0	4.0	4.5	4.8	4.6	4.4	4.4	4.4	5.0	5.0
Western Red Delicious—88	....	....	9.8	7.7	7.0	7.6	7.1	6.8	7.3	7.5	7.8	7.6
Western Red Delicious—100	....	....	7.1	8.4	7.1	6.9	6.7	6.5	6.9	7.0	7.3	7.2
Western Red Delicious—125	....	....	....	7.9	7.9	7.1	7.1	6.5	7.2	7.6	7.9	8.0
Western Golden Delicious—88	....	....	....	11.3	10.0	9.9	9.9	8.0	8.0	10.0	10.0	...
Western Rome—88	10.0	....	....	8.5	8.1	7.2	6.8	6.7	6.4	6.2	6.4	7.3
Western Winesap—88	12.5	12.5	....	....	....	...	...	...	7.1	7.1	7.9	10.0
Western Winesap—125	10.3	....	....	....	....	...	...	...	5.0	5.0	7.1	7.1

costs be reduced wherever possible. It also raises the question as to what grades of fruit the families with incomes of less than $2000 can really afford to buy and how this fruit may be got to them at prices which they can pay.

(*d*) *Secure Shipping-Point Inspection.* Inspection of shipments by federal or state officials is a forward step in the marketing process. Such service is available at nominal cost at the principal shipping points. In the season of 1938–39 the Federal Government inspected 46,840 cars of apples at point of shipment. The demand for the service has increased steadily.

The inspectors certify the grade and condition of the shipments, and their reports constitute legal evidence. This service encourages greater care on the part of shippers and also reduces the rejection of cars at destination for trivial reasons when the market is oversupplied. The inspection system imparts stability and confidence to the market, and is sure to develop as its value is better understood. Inspection costs vary in the different states but average about $4.00 per car. This is the best kind of insurance that the shipper can take out.

Inspection at receiving markets is also available. In the season of 1938–39 the Federal Government made 1614 such inspections. The charge is $4.00 per car for a certificate of grade or $2.50 for an examination of condition of the fruit. Further information relative to inspection may be obtained from the United States Department of Agriculture, or from the various state departments of agriculture.

(*e*) *Load Cars Properly.* This is an important factor influencing the condition in which fruit arrives at destination. Careless loading with open spaces between packages means loss in transit and depreciation on the entire car (Fig. 42). Various systems of loading have been developed, but any satisfactory system requires that the packages be packed firmly in the first place, that they be firmly stacked against the car walls and against each other, and that ventilation be provided to all parts of the car. Any railroad over which fruit is shipped will furnish directions for loading. Broken or defective packages should not be loaded. The collapse of one such package may cause the whole load to shift, resulting in very great damage.

Carloads vary, but will run from 160 to 200 barrels and 360 to 576 bushel baskets. Car capacities are usually figured at 175 barrels and 756 boxes. Barrels and baskets are loaded four tiers high, as a rule. Summer varieties of apples may

(*Merchants Despatch*)

Fig. 42. (*a*) A well-loaded car of tub bushels presenting an attractive appearance at destination. (*b*) Baskets in an improperly loaded car at destination.

sometimes carry better if loaded three tiers high. Minimum carloads are specified by the railroads and take a certain rate. A smaller quantity in the car must go at a higher rate.

The space about the door may be left open, the packages being strongly braced and stayed to prevent shucking. If the packages do not take up all the space in the car, instead of bracing at the doorway, a bulkhead may be built at one end. This should be built according to standard specifications for the packages being loaded.

Refrigerator cars are almost essential for shipment except during the late fall. In warm weather their insulation protects from high outside temperatures. In cold weather, they protect the fruit from freezing. Their use has increased enormously.

It takes many hours to cool fruit that is put in the car at warm temperatures. Ordinarily fruit registers about 75° F. when loaded, or 43° higher than the ice temperature. The rate at which the fruit cools depends largely on its position in the car. The warmest area is in the top layer midway between the door and the bunker. The coldest area is in the bottom layer adjacent to the bunker. Fruit placed at 75° to 80° F. in the car may reach about 45° F. in 12 hours in the bottom layer whereas it may require from 6 to 7 days for the fruit in the top layer to reach 50° F.

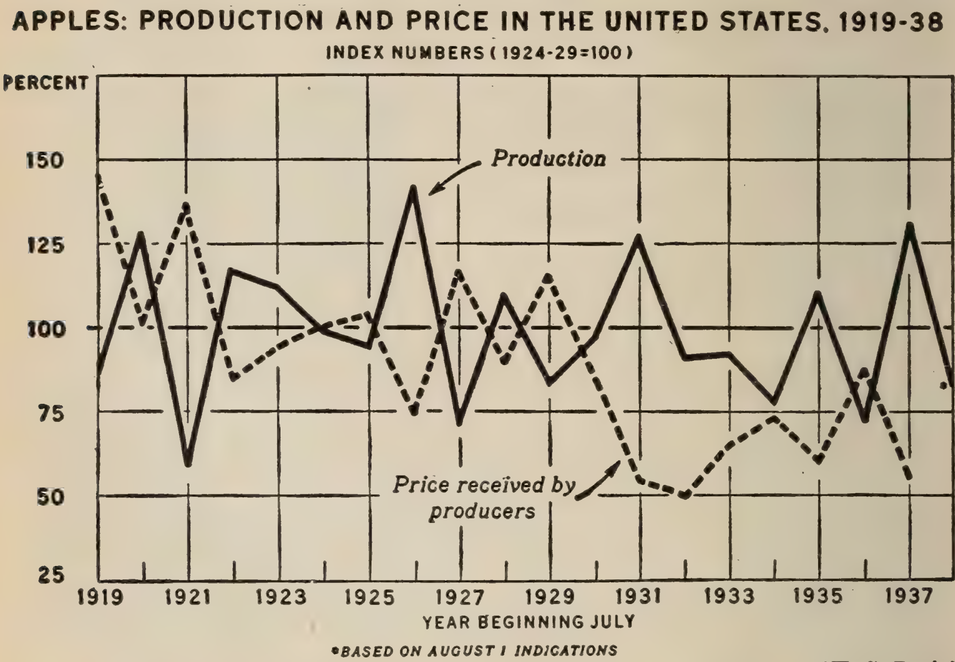
Before the cold air can penetrate to the centers of the packages and cool the fruit properly in all layers, the car may be well on the way to its destination and early and soft varieties of fruit may have ripened considerably. It is desirable, therefore, to load the fruit in the cool of the morning, to put it in so as to facilitate air movement as much as possible, and to arrange for re-icing of the car en route as may be necessary.

In some sections it will be necessary in severe weather to afford additional protection against freezing by lining the car with paper, putting straw on the floor, and using heaters.

Ventilator cars are available on some railroads. They do not provide for icing but are built to permit circulation of air through the car. They are used for fall and winter varieties shipped after the weather is cool but before temperatures are severe. Refrigerator cars are used as ventilator cars for the late and hard varieties of apples when outside temperatures have become sufficiently cool. In such cases the ice is omitted from the bunkers and the hatches are opened when the outside temperature is cold enough for refrigeration but not low enough to cause freezing.

Little has been done as yet in pre-cooling apples in special storage rooms before loading, as is commonly done with citrus fruits. Experiments are being conducted in this regard, as well as in the use of "dry ice."

Information as to procedure in ordering and billing out cars may be obtained from the carriers. Cars should be ordered in writing at least 48 hours in advance of the time when they will be needed. Careful records of all particulars should



(*U. S. D. A.*)

Fig. 43. Apple prices usually vary inversely with production. Since the beginning of the depression, prices have been low in relation to volume of production largely because of decreased consumer buying power.

be kept; such information may be valuable in connection with claims for damages.

(*f*) *Consider Market Preferences and Prices.* The yearly average price received by producers of apples is governed largely by the size of the crop and by changes in the general price level. The variations from year to year in average prices for the season are determined largely by variations in supply. See Fig. 43.

Keeping in mind that the greatest density of population and chief consuming centers are in the territory north of the Ohio and east of the Mississippi Rivers, it is evident from Table 20 that the growers of New England, New York, Maryland, Virginia, Ohio, Michigan, and adjoining states have a favored position with regard to transportation costs. It costs 65.5 cents to put a car of apples with standard ventilation into New York City from Hood River, Oregon, 16 cents from Hancock, Maryland, 26.5 cents from Fennville, Michigan, and 15 cents from Brockport, New York. Even as far west as Omaha the advantage of the Northeastern producing sections is marked.

TABLE 20

FREIGHT RATES ON APPLES, 1940, IN CENTS PER BUSHEL

Destination	Standard Ventilation Point of Origin				Refrigeration Point of Origin			
	Brockport, N. Y.	Hancock, Md.	Fennville, Mich.	Hood River, Ore.	Brockport, N. Y.	Hancock, Md.	Fennville, Mich.	Hood River, Ore.
Atlanta, Ga.	39.5	25	36	60.5	52.83	36.42	48.38	73.06
Boston, Mass.	19	21	27	65.5	27.57	30.04	38.42	78.72
Chicago, Ill.	21.5	23.5	11.5	52.5	31.02	33.97	19.11	62.68
Detroit, Mich.	16	19.5	13.5	65.5	24.57	29.02	21.11	77.40
Louisville, Ky.	22	22.5	17	56.5	32.47	32.97	26.52	67.74
Minneapolis, Minn.	33.5	37.5	23.5	52.5	44.92	49.88	33.97	62.42
New York, N. Y.	15	*12 †16	26.5	65.5	22.61	*19.61 †23.61	36.97	78.06
Omaha, Neb.	41.5	28	32.5	52.5	52.92	40.38	42.97	62.42
Pittsburgh, Pa.	16	13.5	18.5	65.5	23.61	21.11	28.02	77.40
Portland, Me.	20.5	23	28	65.5	30.02	32.04	39.42	78.72
Washington, D.C.	18.5	11	24.5	65.5	28.02	17.66	34.92	78.06

* Export. † Domestic.

Rates are figured on the basis of 50 pounds per bushel. Rates per bushel from Brockport, Hancock, and Fennville are figured on the basis of 175 barrels or 525 bushels per car. Rates per bushel from Hood River are figured on the basis of 756 bushel boxes per car.

It is interesting to note that the rates on apples for export and consigned for that purpose may be less than for domestic use, though the fruit passes through the same points, as shipments from Hancock, Maryland, to New York City.

The Pacific Coast region is under a decided handicap in shipments to all points noted. Refrigeration adds about 20 percent to the rates on long hauls and up to 50 percent on short hauls.

TABLE 21

RELATIVE WHOLESALE NEW YORK CITY APPLE PRICES BY VARIETIES FOR FIFTY-SIX YEARS. BALDWIN TAKEN AS 100

Variety	1879–80 to 1888–89	1889–90 to 1898–99	1899–00 to 1908–09	1909–10 to 1918–19	1919–20 to 1927–28	1928–29 to 1934–35
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Baldwin	100	100	100	100	100	100
Albemarle Pippin	...	...	...	126	138	135
Alexander	120	155	141	125	100	98
Ben Davis	122	113	99	84	74	75
Fall Pippin	101	112	108	109	103	108
Fameuse (Snow)	152	133	121	119	116	99
Gravenstein	128	145	130	115	93	93
Hubbardston	...	106	95	92	88	86
Jonathan	...	...	146	137	105	100
McIntosh	...	...	147	142	155	140
Northern Spy	100	105	104	113	117	121
R. I. Greening	98	110	105	109	115	113
Russet	91	88	82	80	75	73
Tompkins King	130	130	119	107	99	100
Twenty Ounce	113	123	112	109	96	100
Wealthy	...	...	136	120	100	102
Winesap	...	121	122	117	106	94
York Imperial	...	126	116	107	101	97
October to May—average price per barrel for Baldwin*	$2.59	$2.90	$2.90	$3.62	$4.79	$3.73

* Given in terms of barrel because the barrel has been the prevailing package until comparatively recent years. For transfer to bushels, allow 3 bushels per barrel.

Tables 21 and 22, issued by the Department of Agricultural Economics and Farm Management of the New York State College of Agriculture at Cornell University give data on the relative wholesale prices of 17 varieties of apples on

TABLE 22

AUTUMN PRICES BY VARIETIES WHEN WEALTHY PRICES EQUAL 100 *

Variety	Average of Weekly Price Quotations		
	1910 to 1917	1918 to 1926	1927 to 1934
	Percent	*Percent*	*Percent*
Wealthy	100	100	100
Alexander	106	94	95
Astrachan	79	82	82
Baldwin	76	84	103
Ben Davis	78	72	86
Cortland	...	...	102 †
Delicious	...	118	110
Fall Pippin	94	94	112
Fameuse (Snow)	97	96	104
Gravenstein	95	90	96
Grimes	75	76	94
Hubbardston	79	83	94
Jonathan	116	106	106
Maiden Blush	85	86	93
McIntosh	115	134	132
Northwestern Greening	115	107	105
Duchess (Oldenburg)	93	85	85
R. I. Greening	89	98	113
Tompkins King	93	97	100
Twenty Ounce	90	95	115
Wolf River	105	96	99

* For August, September, and October, price relatives were calculated from quotations in the Saturday edition of the *Producer's Price-Current*, New York City. Each quotation in bushel baskets for each grade for each variety was compared with the Wealthy quotation for the same grade.

† Prices for 1932 only.

the New York market compared to Baldwin as a standard for 56 years, and on fall prices of 20 varieties with Wealthy at 100 for 25 years. They are worthy of study as indicating trends over long periods. It is probable that the situation is much the same on other markets.

This information should be of value to the grower in selecting varieties for commercial planting and may also be valuable in determining the proper time to sell. In regard to the former, if the price trend is downward over long periods and if the variety is difficult to grow or handle, or produces a low proportion of fruit packing in the higher grades, it would not seem to be a good planting investment. If a variety does not on the average appreciate in value enough during the storage season to pay storage and overhead charges and return a margin of profit from holding, then it would seem to be best to sell immediately in a normal season. Such factors may, of course, be upset in years of short crops or abnormal conditions. Cold storage has certainly been a considerable factor in extending the season for some varieties in recent years, as many more varieties are at present quoted on the market in January and May than for the early periods of market reports when cold storage was not available.

Taking Baldwin and Wealthy as standard, varieties not selling as well in recent years as formerly are Russet, Ben Davis, York Imperial, Duchess (Oldenburg), Fameuse, and Maiden Blush among others. On the other hand, Northern Spy and Rhode Island Greening have sold relatively better. McIntosh, not quoted until recent years, and Delicious have been selling exceptionally well.

Prices in New York City for apples grown in 1932, 1933, and 1934 averaged about one-third less than the average price of the five preceding crops, 1927–1931, as indicated by Table 23, from the same source as Tables 21 and 22. The largest decrease in price was for McIntosh, 39 percent. Delicious prices decreased only 24 percent. McIntosh prices have decreased more than other varieties, probably because of the increased McIntosh production. Decreases in the main are no doubt due largely to the general depression of price levels.

TABLE 23

RECENT DECLINES IN WHOLESALE APPLE PRICES IN NEW YORK CITY

Variety	Average Price per Bushel for Apples Graded Good to Fancy		
	1927–28 to 1931–32	1932–33 to 1934–35	Decrease
	Cents	*Cents*	*Percent*
McIntosh	259	158	39
Rhode Island Greening	202	132	35
Northwestern Greening	167	111	34
Northern Spy	227	151	33
Wealthy	158	106	33
Wolf River	150	101	33
Albemarle Pippin*	266	184	31
Rome Beauty	187	139	26
Baldwin	181	134	26
Delicious	187	143	24
Average	198	136	31

* Yellow Newtown.

Studies of Consumers' Demand. The New York Food Marketing Research Council in cooperation with the Bureau of Agricultural Economics of the United States Department of Agriculture has made a study of the consumers' demand for apples in New York City. Some 3100 reports from families of the principal nationalities and various income groups were received. The following results are of interest:

1. The housewife is the buyer of fruit as of other supplies for the home. It is to her views and desires that the fruit trade must cater.

2. A very large percentage of housewives know apples only in terms of color—red, green, yellow, etc. This is especially true in the low-income groups, but is evident in all groups.

Among the poorer classes, purchasers of apples on the average do not know a single variety of apples by name, the medium-income group, representing 970 families, knows 1.69 varieties, the group with annual incomes above $6000 knows 3 varieties on the average.

3. Appearance is much more significant than variety names. Large size, high color, and cleanliness of the fruit attract; blemishes, soiled condition, small size, and poor color repel.

4. Orders were placed for the most part either for "eating" or "cooking" apples. Only 24 per cent ordered by variety names, and of these only 13 per cent ordered by brand names.

5. For eating purposes, McIntosh, Baldwin, Fameuse (Snow), Delicious, Northern Spy, Spitzenburg, and Winesap were desired in the order named, with McIntosh considerably in the lead.

Jewish people were especially partial to McIntosh and gave as their reason its high quality. The English, American, and Irish groups favored Delicious and Baldwin. Delicious was the most popular variety among the high-income families.

For cooking purposes green apples or "Greenings" were pre-eminently in demand.

6. Apples are purchased in very small quantities. Thirty-eight percent of the families purchased in units of 12 apples. Units of 10 and 6 apples were also popular. Only 13 per cent purchased in units larger than 12 apples.

Purchases by the pound are usually made in 3- or 4-pound units. Almost no fruit is purchased by the barrel, box, or basket.

7. The use of the apples purchased is: 57 percent are used in the raw state, 15 percent are used for sauce, 13 percent are baked, 11 percent are made into pies, and 3 percent into salads. Italians use more apples in the raw state than any other nationality.

As the family income rises, a larger proportion of the fruit is used in the prepared state and less is eaten raw.

8. The chief reason given for the purchase of apples is their health-giving qualities.

It appears from these studies that attractiveness is the major factor in sales; that publicity relating to varieties, packages, or brands has had a minor effect as yet; that the retailer occupies a position of great significance in influencing purchases; and that the healthful qualities of apples constitute their greatest appeal.

Results in other consuming centers, especially those with populations more uniform in nationality and in economic status, would doubtless be somewhat modified.

By-Products. Dried and canned apples are important by-products of the apple industry. This is evident from Tables 24, 25, and 26. Table 24 lists the quantities of apples and other fruits dried for purposes of comparison. Contrary to the general impression, enormous quantities of apples are

TABLE 24

Production of Dried Fruits 1923–37
U. S. Dept. of Agriculture

	1923	1929	1935	1937
	pounds	*pounds*	*pounds*	*pounds*
Apples.......	19,397,844	44,619,712	71,257,536	52,500,000
Apricots......	54,029,042	43,089,530	49,176,457	44,000,000
Figs.........	....	28,020,931	44,716,293	57,400,000
Peaches......	61,616,496	35,849,539	50,695,693	27,000,000
Prunes.......	245,786,104	347,349,407	473,600,870	512,000,000
Raisins......	380,068,441	421,203,596	414,129,227	580,000,000
Pears........	....	....	14,098,736	16,384,376
Other fruits...	30,903,088	18,565,900	2,885,443	3,748,769
Totals.....	791,801,215	938,698,615	1,120,560,255	1,093,033,145

Increase in total production, 1923–37, 38.0 percent.
Increase in production of apples, 1923–37, 170.6 percent.
Decrease in production of apricots, 1923–37, 18.5 percent.
Increase in production of figs, 1929–37, 104.8 percent.
Decrease in production of peaches, 1923–37, 56.1 percent.
Increase in production of prunes, 1923–37, 108.3 percent.
Increase in production of raisins, 1923–37, 52.6 percent.
Increase in production of pears, 1935–37, 16.2 percent.

dried, more than in the case of other tree fruits with the exception of prunes, and the trend is strongly upward. Under normal conditions there is a good foreign outlet for them.

Table 25 indicates how the canning of apples and the making of applesauce are increasing and the states most active in this connection. The Shenandoah-Cumberland region is a

TABLE 25

CANNED APPLES AND APPLESAUCE, PRODUCTION BY PRINCIPAL STATES 1921–38

(National Canners' Association)

	1921*	1929†	1937	1938
	in standard cases			
California	68,092	Included in "other states"		
Colorado	50,987	Included in "other states"		
Idaho	38,078	30,244	......	......
Maine	301,855	37,630	......	......
Maryland, Pennsylvania, and Virginia	202,985	883,611	3,285,814	1,553,464
Michigan	141,705	166,003	30,009	15,227
New York	601,237	176,313	1,523,705	1,037,263
Oregon	279,751	406,726	280,777	191,714
Utah	27,383	Included in "other states"		
Washington	439,969	1,298,147	658,024	462,007
Other states	87,386	593,877	55,100	22,500
Totals	2,239,428	3,592,551	5,833,429	3,282,175

* Does not include applesauce.

† Statistics for 1929 do not include applesauce; 903,991 cases of applesauce were made in this year, but data upon states in which it was produced were not obtained and cannot now be secured.

very important factor, as is New York State. Table 26 gives a comparison of apples with other fruits.

A study of all three tables indicates that the processing of fruits constitutes a tremendous and growing business. It was felt at one time that the widespread development of cold storage would reduce the by-products industry, perhaps eliminating the drying phases of it. This has not happened to date.

Vinegar and cider manufactured in factories and commercial establishments are of considerable importance. The value

TABLE 26

PACKS OF THE MORE IMPORTANT FRUITS
1921–38
(National Canners' Association)

	1921	1929	1937	1938
	in standard cases			
Apples and	2,239,428	3,592,551	2,672,328	1,755,624
Applesauce		903,991	3,161,101	1,526,551
Apricots	1,150,514	4,267,294	5,727,996	1,729,486
Blackberries	499,414	844,066	493,218	534,248
Raspberries	....	608,335	623,654	319,287
Cherries, red sour	....	1,123,855	2,471,982	1,694,813
Cherries, sweet	990,090	966,017	518,979	730,232
Grapefruit	....	1,174,823	4,279,240	3,645,697
Grapefruit juice	....	115,708	6,016,240	8,021,828
Peaches	5,881,327	8,723,622	13,992,040	10,401,016
Pears	1,256,809	4,980,978	5,115,962	4,848,090
Plums	206,046	171,044	288,532	70,086
Prunes	281,175	1,069,134	1,891,364	934,987
Grapes	54,210	131,542	121,859	93,532
Figs	....	223,857	412,481	260,299
Pineapple	5,895,747	9,210,240	10,922,883	12,203,012
Pineapple juice	....	....	7,500,000	9,000,000 (Estimate)
Fruits for salad and cocktail	....	....	4,408,805	2,880,269
Blueberries and huckleberries	....	232,024	441,988	185,009
Gooseberries	51,851	44,260	57,195	47,287
Loganberries	317,146	354,552	66,978	195,786
Strawberries	....	403,204	126,051	94,860
Olives	675,000	635,000	951,758	742,629
Total	19,498,757	39,776,097	72,262,634	61,914,628

of such products was $10,634,000 in 1933; in 1938 it was $8,563,000 for 44 million gallons. Filtered and pasteurized apple juice has increased in popularity during the last few years. By manufacturing apple jelly, apple flakes, pectin extracts, apple butter, and some other by-products, apple outlets have increased and the low grades appearing on the market have been correspondingly reduced. Every effort which takes this low-grade fruit off the fresh-fruit market would seem to be a movement in the right direction.

(*g*) *Consider Export Markets.* The export market is of great importance to American growers. The proportion of the total crop absorbed by it is not great, but if kept at home it would constitute a surplus which would tend to demoralize home markets. The quantity exported varies with the size of the domestic crop and with the crops in Canada and Europe, particularly in England. Normally from 10 to 12 percent of the commercial apple crop is exported. In late years this has meant about 10 million bushels annually from the United States, though the amount does show substantial variation from year to year (Fig. 44). Canadian apples are preferred, largely because the United Kingdom is the chief importer and gives preference to the products of a member of her family of nations.

Australia and New Zealand ship apples to the British Isles, but as their season is from April to July there is little competition with American apples.

The British Isles ordinarily lead all other countries in imports by a wide margin. London, Liverpool, Glasgow, Manchester, Southampton, Hull, Bristol, and Cardiff are import centers. Transshipment to Ireland takes place from Liverpool and Glasgow. In normal years Germany, the Netherlands, Denmark, Norway, and Sweden have been good customers.

The Central and South American countries import some apples. Argentina, formerly a substantial market, now grows her own apples in large part and restricts importations from the United States. Brazil buys some apples, Chile almost none. The entire population of South America is about 90 million. Governments in recent years have not been too stable, trade restrictions are numerous and exacting, and domestic production is increasing. The outlook for increasing export markets in this direction is not promising.

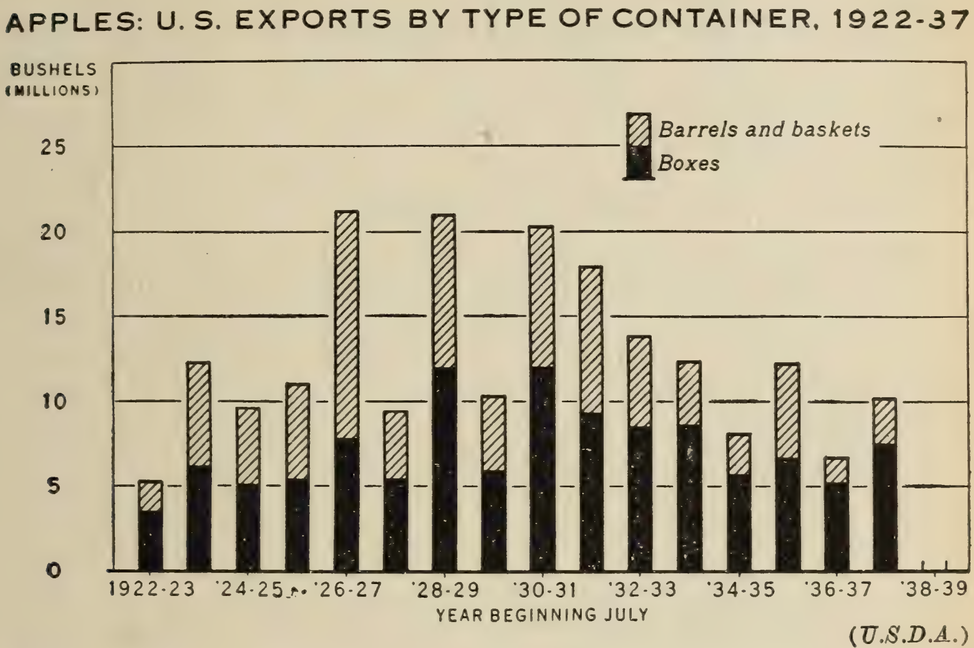


FIG. 44. Total exports of apples from the United States have dropped sharply from the high levels reached in some years prior to 1932. Although exports from all regions are now at a lower level, the greatest relative decline has occurred in exports from the eastern areas which largely pack their export apples in barrels and baskets.

The export outlook in any direction is not hopeful until international relations are stabilized and trade barriers removed.

Export Requirements. Only standard grades and varieties are wanted. The smaller sizes are often in demand, being sold by the pound. The fruit must be firm and tightly packed. The packages must be stored carefully on board ship. Refrigeration is necessary through the fall months. Ventilation of unrefrigerated cargoes is essential. The practice of dumping on European markets fruit which is of a grade and quality too poor to sell elsewhere and which these markets do not want has been the chief obstacle to enlargement of demand.

A steady, uniform, dependable supply of good fruit, honestly packed, is the greatest export need.

Methods of Sale. Shipments may be sent to be sold at auctions, they may be sent on consignment to European firms, or f.o.b. sales may be made to representatives of foreign buyers. Most of the fruit is sold by auction.

II. THE PEACH

More than half the states in the Union produce peaches in commercial quantities (Table 27). Note that production from year to year is very stable in California but fluctuates widely in Georgia, Missouri, and in fact all other states. This is due largely to less equable climatic conditions in these states. The figures are somewhat misleading in that they do not bring out differences in size of the various states. Thus, New Jersey and Delaware, small in area, are really important producing states.

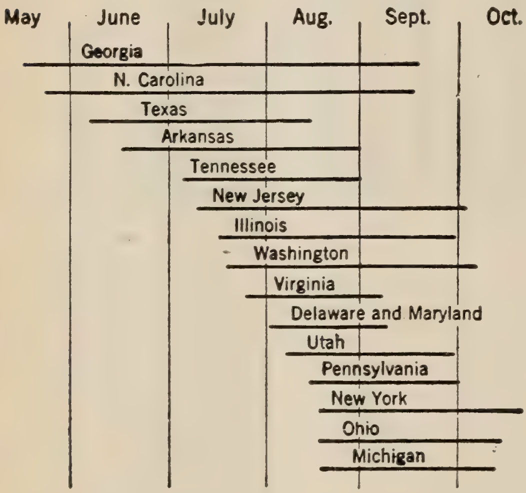


FIG. 45. Peaches: season of major shipment from the chief producing sections. From July 15 to October, the competition is severe in normal seasons.

Georgia begins the shipment of peaches to market in May, followed by California, North Carolina, and Texas. The season of harvest extends gradually northward until the peaches of Ohio, New

TABLE 27

PEACHES — PRODUCTION BY STATES

State	Average 1927–36	1937	1938
	1000 bu.	*1000 bu.*	*1000 bu.*
California *	22,135	23,252	20,835
Georgia	5,824	2,730	5,320
North Carolina	1,813	1,984	2,232
Arkansas	1,584	2,288	2,451
Pennsylvania	1,507	2,673	1,842
Illinois	1,424	2,117	1,425
Michigan	1,354	2,652	1,341
New York	1,348	1,806	1,134
New Jersey	1,330	1,651	1,172
Alabama	1,252	990	1,705
Texas	1,219	1,392	964
Tennessee	1,214	1,860	586
South Carolina	1,095	1,080	1,515
Washington	1,019	935	1,428
Colorado	1,013	1,533	1,388
Ohio	876	1,296	481
Virginia	767	1,599	1,161
Mississippi	750	474	1,061
Missouri	672	1,728	116
Utah	534	72	564
Oklahoma	494	1,073	429
Indiana	456	402	144
Kentucky	452	1,369	352
Maryland	374	448	352
West Virginia	299	528	184
Delaware	271	398	304
Louisiana	240	269	325
Connecticut	172	177	140
United States	52,498	59,724	51,945

*About 50 percent of California production are clingstone varieties used for canning, the remainder are freestone varieties used mainly for drying.

York, and Michigan are sent to market in September, and a few late sorts are available in October (Fig. 45).

Elberta, the main crop peach in all sections other than California, is available from about the middle of July until late September.

Harvesting begins with pruning, spraying, fertilizing, thinning, and general orchard care. The actual picking and packing represent but final acts of an enterprise that has been in process since the pruner went forth to prune.

Packages and other supplies should be ordered as soon as a reasonable idea of the extent of the crop can be determined. Delay in ordering usually means increased costs and may mean much difficulty in securing the packages on time.

Operations:

1. Picking the fruit.
2. Selecting packages.
3. Packing.
4. Loading cars.
5. Storing.
6. Canning and drying.
7. Marketing through cooperative agencies.

1. Picking the Fruit. Picking at the proper stage of maturity is of very great importance in the harvesting of the crop. The fruit which carries the finest color with large size and still reaches the consumer in sound condition commands a premium. With competition from producing sections so keen, it is in many seasons the only kind of fruit that will sell at a profit.

Peaches should be picked when just mature enough to reach market in firm condition, but ready for consumption. This means that if the market is near by the fruit may be left longer on the trees than if a day or more must be spent in transit.

White-fleshed peaches take on a creamy ground color as they approach the picking stage. Peaches with yellow flesh take on a lemon-yellow color away from the sun when ready for harvesting. For distant shipments, fruit must be picked before these color changes are too prominent, or the fruit will be soft on arrival. Beyond this, picking at the proper stage is a matter of experience and knowledge of the varieties.

The length of the picking season will depend very largely on the weather: hot days bring the fruit on with a rush; cool days and nights retard it. In much of the peach belt, the weather may be warm at harvest time and the grower must be prepared to handle the entire crop quickly. The Elberta season usually covers a period of seven to ten days, being reduced in hot, dry seasons to two or three days.

Several pickings should be made from each tree. "Spot" or "color" picking is a standard practice with peaches; it takes into account both size and color. The number of pickings necessary to secure the fruit in the best possible condition to sell at the maximum price depends on the season and the varieties. It is usually necessary to go over the trees three or four times, and some successful growers normally make five or six pickings.

Pick the fruit by taking it gently in the palm of the hand and twisting easily sidewise, so as not to tear the flesh about the stem. Place it carefully in the receptacle. Never press the fruit with thumb or fingers to test its firmness, or bruising will result.

Pickers are engaged by the day under supervision of a competent foreman, or to pick by the package, the former being the more satisfactory method since, though speed is not lost sight of, a greater premium is placed on careful handling. Pickers can usually harvest from 50 to 100 bushels daily, depending upon size of crop on trees, height of trees, amount of "spot" picking necessary, and other factors.

Haul the fruit at once on low spring wagons or motor trucks to some center for packing. This may be an open shed in the orchard, or a more pretentious and permanent establishment. There is no time to lose, and the packing arrangements must be adequate for the crop to be handled.

Picking Equipment. Peach trees are headed low. Much of the fruit can be picked from the ground. A short step-ladder will suffice for the remainder.

Round-stave ½-bushel or ⅝-bushel baskets, padded and with wood or wire handles, are used extensively as picking receptacles. The fruit is carried in them to the packing house. Baskets may be carried under one arm by using a wide strap passing over the shoulder, with large hooks to attach to the basket. This permits use of both hands for picking and avoids

(*Harrison's Nurseries*)

FIG. 46. Three common packages for the peach: from left to right, bushel basket, Georgia carrier, Jersey basket.

the temptation to set the basket on the ground or to attach it to a branch at a distance and drop the fruit into it. The strap may be released easily when the basket is full, and attached to another.

Drop-bottom baskets, or sacks of canvas stretched on wire frames, are coming into extensive use in some sections. The fruit is emptied from them into field boxes holding one bushel and taken to the packing center. Large pails may be used.

Under the system of wide planting, liberal fertilization, and moderate pruning now employed, an average yield of 2½ to 3½ bushels per tree per year may be expected from Elberta. Some varieties exceed these figures.

Elberta bears little the third year and moderately at four years. Some varieties, as Greensboro, may bear marketable quantities the third year.

2. Selecting Packages. The bushel basket is gaining favor as a market package in most sections (Fig. 46). It is the prevailing package in Ohio, Michigan, New York, Texas, Missouri, Maryland, Virginia, and Delaware. It is used extensively in Georgia and other sections, especially for the firmer varieties, including Elberta. The ease and rapidity with which it may be packed commend it.

The tub-type bushel basket is used increasingly. Round-bottom baskets are also used extensively, and half-bushel baskets to some extent.

The Georgia carrier is suitable for some varieties and in some markets. On the whole, however, it is being displaced by the bushel basket. It is especially desirable for tender varieties of fine appearance and high quality and for those shipped long distances. It is used quite extensively in the Georgia belt, and to a small extent in some Maryland, Delaware, and Jersey peach sections.

The carrier is 22 inches long by 11 inches wide and 10 to 10½ inches deep, inside measurements, holding two layers of 4-quart till baskets, three baskets in each layer or six per carrier. Ends, sides, and top are each of one piece. The baskets are 11 inches by 5½ inches wide at bottom and 7¼ inches wide at top, preferably with round corners. A wood divider separates the layers and relieves the fruit in the lower layer from the pressure above. When packed, the carrier weighs from 44 to 50 pounds. The carrier comes from the factory "knocked down" and must be assembled by the grower.

A common package is still the Jersey or Delaware 16-quart splint basket, though the capacity sometimes varies. It is acceptable for local trade, but is not satisfactory for other markets. It is not sufficiently strong or rigid in itself to afford much protection to a fruit that needs considerable. It is easily upset. It is too easily tossed or thrown about, for there is such a thing as having a package that is too easily handled. If used for local trade, a pink or red tarlatan covering lends attractiveness. A rigid wood cover is also available.

The Climax basket is also found in local trade. The box is used in Utah, Colorado, and on the Pacific Coast. It is 5 by $11\frac{1}{2}$ by $18\frac{1}{2}$ inches, inside measurements.

3. Packing. For extensive orchards, packing houses are necessary. In southern sections these are in the orchards or on railroad sidings adjacent to them, cutting the haulage to a minimum. In other sections, as New York, they are operated in connection with cold-storage plants, or the houses used for packing apples are also used for peaches.

A two-story frame house with the top floor for storage is typical in the South. The lower floor where the packing is done is usually open, with a covered driveway.

The fruit is delivered at one side and moves across the house in the packing operations, going into cars at the opposite side.

Matters of lighting and arrangement of equipment must receive careful study. Mechanical devices doing effective sizing are available and are reaching a high state of perfection. They should provide opportunity for sorting the fruit before it goes onto the sizing devices. Mechanical conveyors to save labor are essential.

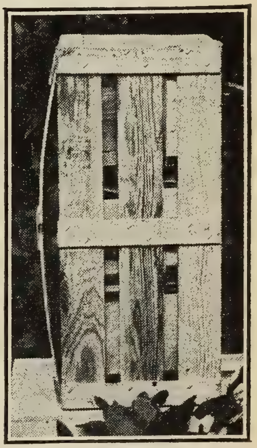
Packing the Bushel Basket. The common style of pack in the bushel basket is the jumble pack with the top layer faced. Proceed as in packing apples in baskets as indicated in Fig. 24. Corrugated paper pads should be placed under the covers, and the cover may be supported by a wooden peg extending from the bottom. Fancy fruit is sometimes placed in layers through the entire basket.

Packing the Georgia Carrier. The fruit is packed in the baskets according to a definite plan, the process being very similar to that of packing apples in boxes, the alternate or diagonal pack being used as illustrated in Fig. 47. A good packer under favorable conditions will pack 150 or more crates per day. The fruit should be graded as to size and color. Two or three grades are usually made, the same grade being

(*New Jersey Exp. Station*)

FIG. 47. Showing the method of packing the baskets in the Georgia carrier.

packed throughout any given package. The carrier, when packed, should show a decided spring or bulge to hold the fruit in place and prevent bruising (Fig. 48). It is loaded on the side.



(*New Jersey Exp. Station*)

FIG. 48. The cover should show a pronounced spring or bulge when the Georgia carrier is packed.

An excelsior pad is placed under the cover. Corrugated paper pads are sometimes used, but afford less protection. The package should be labeled.

Grading Laws. Peaches are packed in most states in accordance with United States grades. Many of the states have adopted these federal grades as their own. In the interest of stabilizing the market and providing a dependable basis for doing business, peach growers should follow the specifications for such grades carefully in packing their fruit.

4. Loading Cars. Fresh fruit shipped several hundred miles should be placed in well-iced refrigerator cars. Shipping instructions on bills of lading usually require that the bunkers be kept full of ice to destination. As much as 2 percent of salt may be specified to reduce the temperature further. Life processes and changes take place very rapidly at high temperatures, and even under refrigeration the fruit in the top layer of packages in a car will go down much more rapidly than that at the bottom.

Pre-cooling, or cooling before shipment, is now practiced to some extent in hot weather and for shipment to distant markets. The fruit is packed quickly after picking. It is cooled down to about 40° F. either in a central station or in special chambers in cold storages, or by forcing cold air through the packed car. The former process gives much better results and is more economical. The fruit is thus reduced to a temperature at the outset as low as or lower than would be attained by former methods after the car had been long in transit. The end-to-end offset style of loading bushel baskets so that the weight of fruit is on the baskets rather than on the fruit is best. The baskets are loaded three tiers high, giving 360 or more baskets per car. About 476 Georgia carriers, loaded on their sides, are placed in a car. Most railroad companies have complete instructions and diagrams for loading. It is well to secure and follow them.

5. Storing. Hard and firm peaches, not overgrown, may be held in cold storage for two to three weeks. Elberta has been held eight weeks when stored immediately after picking, but the risk is great. If held too long, the fruit loses flavor and in any case must be consumed quickly after removal from storage. The proper storage temperature is from 30 to 32° F.

Owing to the progressive ripening from south to north of all varieties, the storage of peaches seldom presents an advantage. In past years this practice had merit in giving the grower an opportunity to wait for a favorable market. This advantage is almost entirely dissipated now as the various sections provide a continuous supply throughout the season.

6. Canning and Drying. Canning factories take large quantities of peaches in some Eastern sections. In California the fruit is both canned and dried. Most of the work is done by machinery, including pitting the fruit. The trade demands a firm yellow peach for canning, and a clingstone variety holds its shape better than a freestone sort. A red color about the pit discolors the syrup and is not wanted.

The canning industry in California has reached very large proportions, 90 percent of the pack being made from yellow clingstone varieties, such as Tuscan, Orange, Peaks, and Phillips.

In the East, thus far the canning factories have taken the surplus yellow peaches of several kinds. More attention needs to be paid to the selection and development of proper canning types.

The evaporation or drying of peaches is practiced on a large scale in California, where the climate is very favorable for this purpose. The dried peach is an excellent fruit product. It is questionable whether Eastern sections where it would be necessary to work under cover, with artificial heat, can ever compete in this field.

7. Marketing through Cooperative Agencies. The peach, like the apple, is packed and marketed extensively through cooperative organizations, the grower being relieved of all responsibility after he delivers the fruit at the packing house.

All the advantages of cooperative apple marketing hold here plus the fact that the peach is a fruit that must be marketed without delay. A large enterprise devoting all its attention to packing and marketing should on the whole and over a period of years perform this service better for a group of individuals than each man could do it for himself. The large grower may constitute an exception.

Custom sheds where packing is done at a price which covers cost plus a small profit to the operator have given good service in some sections. The grower may or may not handle the sale of his own crop.

III. THE PEAR

The pear must be picked while still hard and firm. Ripened on the tree, it is likely to be coarse and stringy or sometimes gritty, and the center may turn brown before the exterior shows signs of deterioration. Out of storage, and with the exception of certain winter sorts, it reaches its maximum condition and passes on to softening and decay quickly, thus again emphasizing the necessity for picking at the proper time and

(*U. S. D. A.*)

FIG. 49. Picking Bartlett pears in an Oregon orchard. Note clean cultivation and picking equipment.

for prompt handling. Table 28 indicates the chief producing areas.

1. Picking. In practice pick pears while green in color, but with a decided tendency toward a lighter shade. If the fruit is to go into consumption immediately, it may be permitted to hang longer than if it must be held for some time. The fruit often makes a marked increase in size during the late stages of development, and the grower will wish to get the benefit of this increase so far as he may without incurring loss in other directions. The sugar content is higher in fruit left longer on the trees than in that picked earlier. Pears picked too green lack flavor and are likely to shrivel instead of ripening. Shriveling occurs because the lenticels in the skin of the fruit are not corked over, so that evaporation takes place rapidly.

When pears picked at too immature a stage finally ripen, not only are they lacking in sugar content and quality, but also they break down and decay very quickly. Pears picked at a later stage remain in good condition for a much longer time after softening. Bartletts intended for cold storage or for canning should be a "light green to turning." Pears picked very late and canned have an unattractive, chalky color, a cloudy syrup, and an insipid flavor.

Experience and careful attention each season as the crop approaches maturity are necessary to determine the proper picking stage.

Picking methods, equipment and containers resemble those for the apple.

2. Packages and Packing. Packages for the pear are not well standardized. The bushel basket, the standard pear box, and the half-box are all used by some growers and for some varieties.

The pear box and half-box in which each specimen is wrapped are used in the West; the bushel basket and Eastern apple box, in other sections. Bushel crates are also used for canning factories and for storage. Climax baskets are found on local markets. Placing the pears in layers and facing them so improves the appearance of the pack as often to make the operations worth while, when the fruit is sold in the fresh state.

On account of the shape of the fruit, grading machines have not found as much favor as for apples and peaches, but peach graders are used to some extent, as well as machines that size by weight, for sizing pears.

3. Canning and Drying. Canning factories in some sections take much of the fruit, providing a dependable outlet and stabilizing prices. The fruit must be hand-picked and

TABLE 28

PEARS — PRODUCTION BY STATES 1937–39 *

State	1937	1938	1939	Average
	1000 bu.	*1000 bu.*	*1000 bu.*	*1000 bu.*
California	9,334	11,751	10,334	10,473
Washington	5,600	6,500	5,779	5,960
Oregon	3,550	4,249	4,229	4,010
New York	1,305	1,960	1,749	1,672
Michigan	1,380	1,411	1,354	1,382
Ohio	992	634	956	861
Pennsylvania	817	657	918	798
Illinois	999	413	724	712
Indiana	630	366	527	508
Texas	412	440	406	420
Missouri	684	66	426	392
Mississippi	157	462	348	323
Virginia	416	334	189	313
Georgia	244	404	281	310
Alabama	211	383	313	303
North Carolina	281	364	230	292
Kentucky	411	135	206	251
Tennessee	284	186	244	238
Arkansas	214	156	211	194
Kansas	282	56	151	163
All others	1,345	1,546	1,335	1,409
United States	29,548	32,473	30,910	30,984

* Source of date: United States Department of Agriculture.

carefully handled, and small sizes are not wanted. Bartlett and Kieffer are the varieties in greatest demand for canning.

Pears are dried on the Pacific Coast, but not in the East at the present time.

4. Storage and Refrigeration. Bartlett and other standard varieties keep well in cold storage, if properly handled. No time should be lost after the fruit is picked in getting it cooled down and into storage. For best results, Bartlett pears should be held at a temperature of 28 to 30° F. and Bosc at 30 to 32° F. Fruit picked in proper condition may be held several months. The desirable cold-storage period for Bartletts intended for canning does not extend beyond 60 days. In any event Bartletts intended for canning later or for the fresh market should be removed from the storage before they acquire a pronounced yellow shade, this color change being a dependable danger signal. When removed from storage, the fruit should be permitted to ripen at a temperature of 60 to 70° F. in order to develop the highest quality.

Shipment in refrigerator cars is usually necessary except for late varieties.

Pre-cooling is advisable for long shipments coming from sections where the fruit has poor carrying qualities.

5. Export Markets. The export demand is not large. Canada takes a considerable quantity. Some fruit goes to Central America and Brazil, some also to the British Isles and Continental Europe. The European countries take mostly the boxed pears of the West Coast states.

6. Yields. Extensive records of an authentic nature on pear yields in the Eastern states are not available, but the trees are less productive and come into bearing more slowly than in the Pacific Coast states. Bartletts yield 140 to 160 bushels of packed fruit per acre on the average, Seckel about 125 bushels, and Kieffer about 210 bushels.

In California, Bartletts reach commercial production at 6 to 7 years; at 12 years and thereafter, 10 tons or 400 boxes per acre is a fair average yield, larger yields being quite common. Bosc will yield about 300 boxes per acre; Anjou, otherwise desirable, is a very light and variable cropper; Clairgeau yields about the same as Bartlett, and Winter Nelis produces about 300 boxes per acre, on the average.

IV. THE PLUM

1. Picking. The fruit should be picked before it is fully ripe. Many varieties when ripe are soft, bruise easily, and go down quickly. Brown rot infection is liable to occur in humid sections and may wipe out most of the crop if the fruit is left on the trees too long.

On the other hand, there has been a tendency to pick the fruit before it has much flavor, and these partly grown plums have seriously injured the demand for a really fine fruit. For jam and jelly the fruit should not be fully ripe, but for dessert purposes and for canning more mature fruit is much to be preferred. The sugar content, color, and quality are much better. The custom is to pick the Japanese or Salicina varieties, as Burbank and Abundance, well in advance of maturity. Such thick-fleshed varieties as Italian prune may be left much longer; in fact, they are still unripe for some time after they have colored well.

Picking equipment and methods are much the same as for other fruits. Care should be exercised not to tear the flesh of the fruit or to destroy the natural bloom. If the fruit is jerked in a direct pull from the spur, the stem will be torn out and the flesh ruptured. The picker should give a slight upward turn so that the stem separates from the spur and remains attached to the fruit. Tin pails or small baskets are suitable picking receptacles.

It is necessary to make from two to five pickings, depending on the variety and season, to secure the fruit in the most favorable condition for market. Some varieties, including Italian prune, take on considerable color after picking. In the West, prunes for drying are shaken from the tree by jarring the branches with padded poles and the fruit is picked up from the ground. Some American plums are shaken from the tree, dropping on canvas or cloth covers spread on the ground.

Table 29 indicates the areas of commercial production of both plums and prunes, whether fresh or dried. There are, however, many local areas in other states where plums may be and are grown to advantage.

2. Packing. For the canning trade and for jam, the bushel basket is the standard package. For the retail market, climax baskets of varying sizes with slat covers are used.

Plums from California are packed in crates holding four baskets each. Each basket is about 8 inches square on top, 6½ inches square on the bottom, and 4 inches deep, inside measurements. The sides are therefore sloping. The baskets are made of thin veneer with a strip of tin fitted about the top edges. Tissue paper is laid in the bottoms and sometimes paper or veneer dividers or "shims" are placed between layers. The fruit is packed much like peaches in till baskets or apples in boxes.

California and Idaho plums come East in large quantities under refrigeration. They are a considerable factor in the market.

3. Storing. Plums may be held for extended periods in cold storage, if they are free from brown rot, handled carefully, and put in storage at once after picking. The extent of the storage period depends on the variety but ranges from three to ten or twelve weeks.

The best storage temperature seems to be about 32° F.

4. Prunes. A prune is a plum with flesh thick and meaty enough to make it an acceptable product when dried. Prunes in the East are grown for canning or for the retail market, and harvesting methods do not differ from those for plums.

In the Pacific Coast states prunes are dried, chiefly by the sun in California, and by artificial heat in Oregon and Washington. This is a distinct and highly specialized phase of fruit growing not treated in detail here. It is not probable that other sections will ever compete in this branch of the industry with the Pacific Coast, where heavy yields and favorable climatic conditions for drying are pronounced.

TABLE 29

PLUMS AND PRUNES — PRODUCTION AND USE BY STATES

Crop and State	Average 1927–36	1937	1938
	Tons	*Tons*	*Tons*
	Fresh Basis		
Plums:			
Michigan	5,600	5,800	2,900
California	60,900	66,000	64,000
2 States	66,500	71,800	66,900
Prunes:			
Fresh Use:			
Idaho	19,470	12,900	15,400
Washington	14,520	10,400	16,200
Oregon	14,420	11,000	15,000
3 States	48,410	34,300	46,600
Canned: *			
Washington	3,330	4,500	3,000
Oregon	11,270	22,500	18,000
2 States	14,600	27,000	21,000
	Dry Basis		
Dried: †			
Washington	3,780	700	1,100
Oregon	25,250	6,500	15,000
California	196,200	249,000	221,000‡
3 States	225,230	256,200	237,100‡

* Includes small quantities for cold packing.

† To convert California dried prunes to fresh basis, multiply by 2½. In Washington and Oregon, the ratio ranges from 3 to 4 (fresh) to 1 dried.

‡ Includes standard and substandard prunes held in reserve pools. In addition to the 221,000 tons of dried prunes, an equivalent of 60,000 tons (dry basis) was not harvested because of market conditions and 4000 tons (dry basis) were lost in the drying process.

5. Yields. In the East 3 to 5 tons per acre may be expected from a mature orchard in good condition, or 1 to 1½ bushels per tree. The average for all orchards is much less. Prune trees often yield 2 to 3 bushels per tree. The Japanese or Salicina varieties come into bearing at 3 to 5 years of age; the Domestic varieties, about 2 years later. The native American plums require a longer period.

On the Pacific Coast the trees tend to come into bearing earlier and to produce larger crops than elsewhere.

V. THE CHERRY

The picking period for cherries is usually short. It is largely determined by the weather, except in the Pacific Coast states. Varieties also differ greatly in length of picking season. The soft-fleshed, juicy kinds mature and deteriorate rapidly. The firmer and drier varieties give the grower more time to handle them. Among the sour cherries, English Morello is noted for the extended period that it will hang on the tree. Some growers in the East have found that, after being dusted lightly with sulphur just before picking, the fruit will hang much longer without breaking down, because of the prevention of brown rot infection.

Table 30 indicates the regions of commercial cherry production in the United States. The Pacific Coast states are the heaviest producers of sweet cherries, though New York and Michigan have substantial plantings. The latter states, with Wisconsin and Pennsylvania, produce the bulk of the sour cherries, mostly of the Montmorency variety.

Most sour cherries go to market without further grading after picking. Sweet cherries and fancy lots of sour cherries should be run by putting small quantities on burlap packing frames or tables and sorting carefully by hand. Women do this work extensively.

Sour cherries are seldom faced, but sweet cherries of

TABLE 30

Cherries — Production, Including Sweet and Sour, by States

State	Average 1927–36	1937	1938
	Tons	*Tons*	*Tons*
New York	17,275	21,750	16,360
Sweet	2,188*	1,770	1,440
Sour	16,849*	19,980	14,920
Pennsylvania	7,308*	9,890	6,560
Ohio	4,499*	7,340	3,630
Michigan	26,838	35,840	14,940
Sweet	......	2,287	2,240
Sour	.....	33,553	12,700
Wisconsin	7,664	13,500	9,440
Montana	474	340	470
Idaho	2,775	1,600	2,490
Colorado	3,300	3,460	5,280
Utah	3,108	2,100	4,270
Washington	14,230	13,500	25,500
Oregon	12,780	13,800	21,400
California	18,420	21,600	28,800
12 states	116,309	144,720	139,140

* Short-time average.

fancy varieties are turned stems under so that the top of the package is very attractive.

In large orchards in some sections, movable packing houses, mounted on skids, are used. These are hauled from place to place through the orchard as picking progresses.

Delivery is usually made to the canning factory in bushel or half-bushel baskets without sorting or grading the fruit. Eight-pound climax baskets are used for this purpose in some sections. Payment is made by the pound, often on contracts made in advance.

1. Selling. Cherries are sold through the usual market channels. Fruit from the Pacific Coast is handled through cooperative organizations; such associations also function in Wisconsin and Michigan districts. Some shipments of cases by express direct to the consumer and retailer occur. Sales of larger quantities are often made on track at the shipping point.

A few cherries from the Pacific Coast appearing on the market very early in the season are shipped, in express cars, in ice chests holding 10 to 12 standard boxes. Later shipments are made in refrigerator cars.

2. Cold Storage. Sour cherries, as Montmorency, in prime condition will keep for about two weeks in cold storage. Beyond this point they are likely to shrivel. Sweet cherries of the black varieties may be held longer, sometimes four weeks, though this is variable with the variety and the district where grown. The light-colored sweet varieties soon discolor. The proper storage temperature for cherries is about 32° F.

3. Frozen Fruit. Cherries for pies, soda fountains, etc., are increasingly stored in the frozen state. They are cooled in vats of water and ice, pitted by machine, and packed either with or without sugar in barrels, tubs, pails, or cardboard containers covered with paraffin. They are frozen at temperatures around zero and then held in a frozen condition until used.

4. Yields. In the canning sections of the East, 3 to 4 tons per acre of sour cherries is a good yield, 6 tons are occasionally secured, and larger yields are recorded.

Figure 50 indicates the average yield now obtained from Montmorency cherry trees of different ages in Michigan. Minor irregularities in the graph should be disregarded, and the general trend as indicated by the heavy line should be noted. The period from 17 to 25 years is most productive, but at best exceeds only slightly 50 pounds per tree, or something over 5000 pounds per acre. These figures include orchards on good and poor soils, in good and poor locations. A good orchard in the proper location should do much better. Indeed, the statement is made that "substantial profits can be realized only where production costs per pound can be kept low by obtaining yields well over the general average of 50 pounds per tree." It is interesting to note that orchards located under favorable conditions and receiving good care were bearing profitable crops at ages much in excess of 25 years.

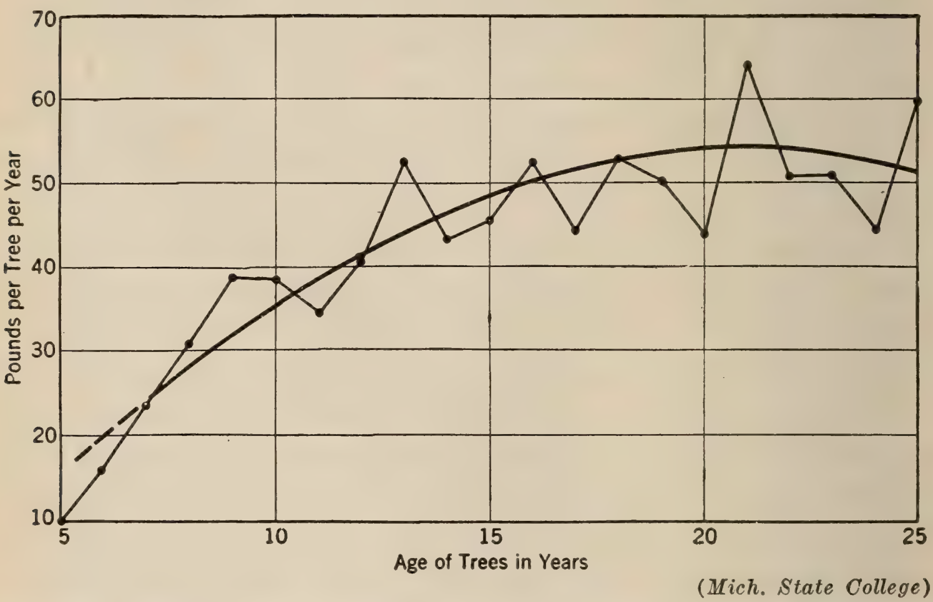


Fig. 50. Yields obtained from Montmorency cherry trees at different ages in Michigan.

Sweet cherries yield less than sour but as a rule bring a higher price. In the Pacific Coast section sweet cherries yield much more heavily than in the East.

A critical point in cherry production is the ability to mobilize a sufficient number of pickers in a short period. The prospective grower will take this into account in making his plans, and the grower already in the business will prepare carefully for the harvest period. Among sour cherries Early Richmond, Montmorency, and English Morello ripen in the order given. Girls are often hired for picking. Some large growers have established camps in which pickers may live during the harvest season.

5. Picking. Fruit that goes to the retail market is picked with the stems on and before it is fully ripe. Since the fruit improves markedly in size and appearance in the later stages of maturity, it is advisable not to pick sooner than necessary to reach the market in good condition. The picker grasps the stems, rather than the fruit, taking care not to break off the spurs or the buds. Some growers of fruit for a high-class trade prefer to use shears to clip the stems. Fancy cherries, especially the sweet varieties, must be handled with the utmost care, since they readily show the effects of bruising. Fruit for market can be picked only when the weather is dry, as wet cherries mold and rot quickly.

Sour-cherry trees are usually low enough so that the fruit not reached from the ground may be picked from a tripod ladder. For higher-growing sweet varieties the usual orchard ladders also may be needed. Picking receptables may be 5- to 10-quart pails or baskets holding from 6 to 10 pounds. Straps run through the handles and tied about the waist, or books for hanging the receptacle on the branches, permit the use of both hands for picking. Pickers may be paid by the day or piece.

The quantity picked in a day depends upon the size of the crop, the type of tree, and the proficiency of the picker, varying from 100 to 300 pounds per day in most sections. Probably 200 pounds is an average when the trees are carrying good crops. Women and girls make good pickers.

Large quantities of cherries go to the canner. For this purpose the fruit is permitted to hang until fully ripe. It should be stripped from the trees without stems, if it is to be canned at once, since this saves the cost of stemming. However, such fruit will go down almost immediately after picking and must be processed without delay.

Some growers sell their whole crop to juice manufacturers or to packers of frozen fruit.

For canning purposes, only one picking is made as a rule. For market, several pickings may be necessary, the number depending on the variety and the season.

6. Packing. The 24- and 32-quart crates such as are used for berries are common shipping packages, particularly for sour cherries. Wisconsin uses largely the 16-quart crate, as do some other sections. The climax grape basket, holding from 4 to 12 quarts, is also a popular package on some markets. In New Jersey 16- and 20-quart baskets are used extensively. Western sweet cherries are packed for Eastern markets in 8- or 10-pound boxes, or flats.

VI. THE QUINCE

1. Picking. The quince is tender and shows bruises readily. It should be picked carefully into padded baskets or pails, when the fruit changes in ground color from deep green to a lighter shade.

The fruit is used chiefly for jellies, for which it is very popular, for jams, and to some extent for baking and canning. It is frequently combined with other fruits in various preparations to lend a distinctive flavor.

2. Packing. The apple barrel is sometimes used, but is too large a package for so tender a fruit. Climax grape baskets holding from 8 to 12 quarts are desirable packages. The bushel basket and the Eastern apple box should make good packages.

3. Storage. Though commonly sold in the fall, the quince, if mature but hard and carefully handled, may be held in cold storage for several months and in common storage for a shorter period. Green, immature fruit scalds readily in storage, and fruit affected with scab is not a good storage risk. No experimental work to determine proper storage temperatures has been done, but prevailing opinion indicates that the fruit should be held at a somewhat higher temperature than most fruits, probably about 35° F.

4. Yields. Some fruit will be borne at five and six years of age, but a commercial crop cannot be expected before the trees are eight to ten years old. A half-bushel per tree is a good crop; in certain years the average may reach a bushel per tree and individual trees may produce in excess of two bushels.

The tree is long of life, unless cut off by fire blight or other factors—from 25 to 50 years, depending on conditions.

GENERAL INFORMATION

I. OFFICIAL U. S. STANDARDS FOR THE INSPECTION OF APPLES

Grade Requirements

U. S. Fancy shall consist of apples of one variety which are mature but not overripe, carefully handpicked, clean, fairly well formed; free from decay, internal browning, internal breakdown, scald, freezing injury, unhealed broken skins, and bruises (except those incident to proper handling and packing), and visible water core. The apples shall also be free from damage caused by russeting, sunburn, spray burn, limb rubs, hail, drought spot, scars, disease, insects, or mechanical or other means. Each apple of this grade shall have the amount of color specified hereinafter for the variety. (See Tolerances and Condition after storage or transit.)

U. S. No. 1. The requirements for this grade are the same as U. S. Fancy except that less color is required for all varieties except yellow and green varieties, for which the requirements for both grades are the same. Apples of this grade shall be of one variety, mature but not overripe, carefully handpicked, clean, fairly well formed; free from decay, internal browning, internal breakdown, scald, freezing injury, unhealed broken skins, and bruises (except those incident to proper handling and packing), and visible water core. The apples shall also be free from damage caused by russeting, sunburn, spray burn, limb rubs, hail, drought spot, scars, disease, insects, or mechanical or other means. Each apple of this grade shall have the amount of color specified hereinafter for the variety. (See Tolerances and Condition after storage or transit.)

U. S. Commercial shall consist of apples of one variety which meet the requirements of U. S. No. 1 except as to color. This grade is provided for apples which are mature but which do not have sufficient color to meet the specifications of U. S. No. 1. (See Tolerances and Condition after storage or transit.)

U. S. No. 1 Early shall consist of apples of one variety which meet the requirements of U. S. No. 1 except as to color and maturity. Apples of this grade may have no red color and need not be mature. This grade is provided for early varieties only, such as Oldenburg (Duchess of Oldenburg), Gravenstein, Lowland Raspberry (Liveland Raspberry), Red June, Summer Hagloe, Twenty Ounce, Wealthy, Williams, Bailey Sweet, Bietigheimer, and other varieties which ripen at the same period and which are often used for cooking rather than for eating out of hand. (See Tolerances and Condition after storage or transit.)

U. S. Utility shall consist of apples of one variety which are mature but not overripe, carefully handpicked, not seriously deformed; free from decay, internal browning, internal breakdown, scald, freezing injury, and unhealed broken skins. The apples shall also be free from serious damage caused by dirt or other foreign matter, bruises, russeting, sunburn, spray burn, limb rubs, hail, drought spot, scars, visible water core, disease, insects, or mechanical or other means. (See Tolerances and Condition after storage or transit.)

U. S. Utility Early shall consist of apples of one variety which meet the requirements of U. S. Utility except as to maturity. Apples of this grade need not be mature. This grade is provided for early varieties only, such as Oldenburg (Duchess of Oldenburg), Gravenstein, Lowland Raspberry (Liveland Raspberry), Red June, Summer Hagloe, Twenty Ounce, Wealthy, Williams, Bailey Sweet, Bietigheimer, and other varieties which ripen at the same period and which are often used for cooking rather than for eating out of hand. (See Tolerances and Condition after storage or transit.)

Combination Grades. Combinations of the above grades may also be used as follows:

Combination U. S. Fancy and U. S. No. 1.
Combination U. S. No. 1 and U. S. Commercial.
Combination U. S. No. 1 and U. S. Utility.

Combinations other than these are not provided for in connection with the United States apple grades. When combination grades are packed, at least 50 per cent of the apples in any container shall meet the requirements of the higher grade in the combination. (See Tolerances and Condition after storage or transit.)

U. S. Hail Grade shall consist of apples which meet the requirements of U. S. No. 1 except that hail marks where the skin has not been broken and well-healed hail marks where the skin has been broken shall be permitted provided the apples are fairly well formed. (See Tolerances and Condition after storage or transit.)

Unclassified shall consist of apples which are not graded in conformity with any of the foregoing grades.

Color

In addition to the foregoing requirements for U. S. Fancy and U. S. No. 1 each apple of these grades must have the percentage of color shown in the table on page 136.

For the solid red varieties the percentage stated refers to the area of the surface which must be covered with a good shade of solid red characteristic of the variety, except that an apple having color of a lighter shade of solid red or striped red than that considered as good shade of red characteristic of the variety may be admitted to a grade, provided it has sufficient additional area covered so that the apple has as good an appearance as one with the minimum percentage of good red characteristic of the variety required for the grade.

For the striped red varieties the percentage stated refers to the area of the surface in which the stripes of good shade of red characteristic of the variety shall predominate over the stripes of lighter red, green, or yellow. However, an apple having color of a lighter shade than that considered as good shade of red characteristic of the variety may be admitted to a grade, provided it has sufficient additional area covered so that the apple has as good an appearance as one with the minimum percentage of stripes of good red characteristic of the variety required for the grade. Faded brown stripes shall not be considered as color except in the case of the Gray Baldwin variety.

Definitions of Terms

As used in these grades:

1. "Mature" means having reached the stage of maturity which will insure the proper completion of the ripening process.

Before a mature apple becomes overripe it will show varying degrees of firmness, depending upon the stage of the ripening process. The following terms are used for describing these different stages of maturity of apples:

(*a*) "Hard" means apples with tenacious flesh and starchy flavor. Apples at this stage are suitable for storage and long-distance shipment.

(*b*) "Firm" means apples with tenacious flesh but becoming crisp with a slight starchy flavor, except the Delicious variety. Apples at

Variety	U. S. Fancy	U. S. No. 1	Variety	U. S. Fancy	U. S. No. 1
	Percent	Percent		Percent	Percent
Solid red:			Striped or partially red—Continued		
Aiken Red	50	25	Salome	33	15
Arkansas Black	50	25	Stayman Winesap	33	15
Black Ben	50	25	Sutton	33	15
Detroit Red	50	25	Tompkins King	33	15
Esopus Spitzenburg	50	25	Wagener	33	15
Gano	50	25	Wealthy	33	15
King David	50	25	Willowtwig	33	15
Lowry	50	25	York Imperial	33	15
Opalescent	50	25	Other similar varieties	33	15
Virginia Beauty	50	25	Stark	25	10
Winesap	50	25	Hubbardston	25	10
Other similar varieties	50	25	Other similar varieties	25	10
Striped or partially red:			Red June	33	(*)
Jonathan	50	25	Williams	33	(*)
Kinnard	50	25	Other similar varieties	33	(*)
McIntosh	50	25	Gravenstein	25	(*)
Missouri Pippin	50	25	Jefferies	25	(*)
Other similar varieties	50	25	Oldenburg (Duchess of Oldenburg)	25	(*)
Arkansas (Mammoth Black Twig)	33	15	Red Astrachan	25	(*)
Delicious	33	15	Shiawassee	25	(*)
Baldwin	33	15	Smokehouse	25	(*)
Gray Baldwin	33	15	Summer Rambo	25	(*)
Ben Davis	33	15	Twenty Ounce	25	(*)
Bonum	33	15	Other similar varieties	25	(*)
Fameuse	33	15	Red cheeked or blushed:		
Limbertwig	33	15	Hyde King	(†)	None
Nero	33	15	Maiden Blush	(†)	None
Northern Spy	33	15	Monmouth (Red Cheeked Pippin)	(†)	None
Ontario	33	15	Winter Banana	(†)	None
Paragon	33	15	Other red cheeked or blushed varieties	(†)	None
Ralls (Geneton)	33	15	Yellow or green varieties	(‡)	(‡)
Rainier	33	15			
Rome Beauty	33	15			

* Tinge of color. † Blushed cheek. ‡ Characteristic color.

this stage are also suitable for storage and long-distance shipment.

(*c*) "Firm ripe" means with crisp flesh except that in apples of the Gano, Ben Davis, and Rome Beauty varieties the flesh may be slightly mealy. Apples at this stage may be shipped long distances but should be moved into consumption within a short period of time.

(*d*) "Ripe" means mealy and soon to become soft for the variety. Apples at this stage should be moved immediately into consumption.

2. "Overripe" means dead ripe, very mealy or soft, past commercial utility.

3. "Carefully handpicked" means that the apples do not show evidence of rough handling or of having been on the ground.

4. "Clean" means free from excessive dirt, dust, spray residue, or other foreign material.

5. "Fairly well formed" means that the apples may be slightly abnormal in shape but not to an extent which detracts materially from the appearance of the fruit.

6. "Seriously deformed" means so badly misshapen that the appearance is severely affected.

7. "Damage" means any injury or defect which materially detracts from the appearance or keeping quality of the apples.

(*a*) Russeting which exceeds the following shall be considered as damage:

Russeting which is excessively rough on Roxbury Russet and other similar varieties.

Russeting on other varieties which covers a total area of more than 25 per cent of the surface in the aggregate except that—

(1) Smooth, solid russeting which covers an area of more than 10 percent of the surface in the aggregate shall be considered as damage unless the russeting is within or continuous with that in the stem basin or calyx cavity, in which case an additional 15 percent shall be permitted provided that the total area covered shall not exceed 25 percent in the aggregate.

(2) Slightly rough russeting which covers an area of more than 15 percent of the surface if confined to the stem basin or calyx cavity or continuous therewith, or such russeting which covers an area of more than one-half inch in diameter if it is not continuous with the russeting in the stem basin or calyx cavity, shall be considered as damage.

(3) Rough russeting which is well within the stem basin and is not readily apparent shall be permitted, but any other rough russeting which exceeds one-quarter inch in diameter shall be considered as "damage."

Any one of the following defects, or any combination thereof, the seriousness of which exceeds the maximum allowed for any one defect, shall be considered as damage:

(*b*) Sunburn or spray burn which has caused blistering or cracking of the skin or when the discolored area does not blend into the normal color of the fruit unless the injury can be classed as russeting (7*a*).

(*c*) Dark brown or black limb rubs which affect a total area of more than one-half inch in diameter or light brown limb rubs which affect a total area of more than 1 inch in diameter.

(*d*) Hail marks, drought spots, or other similar depressions or scars which are not superficial or where the injury affects more than one-half inch of the surface in the aggregate.

(*e*) Disease. Scab spots which are not corked over or corked-over scab spots which affect a total area of more than one-fourth inch in diameter.

Cedar-rust infection which exceeds in the aggregate an area of one-quarter inch in diameter.

Sooty blotch or fly speck which is thinly scattered over more than one-tenth of the surface, or dark, heavily concentrated spots which affect an area of more than one-half inch in diameter.

(*f*) Insects. More than two healed insect stings or any healed insect sting which is over one-eighth inch in diameter exclusive of any encircling discolored ring.

Worm holes.

8. "Serious damage" means any injury or defect which seriously detracts from the appearance or keeping quality of the apples

(*a*) Russeting which exceeds the following shall be considered as serious damage:

Smooth solid russeting which affects more than one-half of the surface in the aggregate, including any russeting in the stem basin, or rough or barklike russeting which detracts from the appearance of the fruit to a greater extent than the smooth solid russeting permitted, provided that any amount of russeting shall be permitted on Roxbury Russet and similar varieties.

Any one of the following defects or any combination thereof, the seriousness of which exceeds the maximum allowed for any one defect shall be considered as serious damage:

(*b*) Sunburn or spray burn which seriously detracts from the appearance of the fruit.

(*c*) Limb rubs which affect more than one-tenth of the surface in the aggregate.

(*d*) Hail marks, drought spots or scars, if they materially deform or disfigure the fruit, or if such defects affect more than one-tenth of the surface in the aggregate, provided that no hail marks which are unhealed shall be permitted and not more than an aggregate area of one-half inch shall be allowed for well-healed hail marks where the skin has been broken.

(*e*) Visible water core which affects an area of more than one-half inch in diameter.

(*f*) Disease.

Scab spots which are not corked over or corked-over scab spots which affect a total area of more than three-fourths inch in diameter.

Cedar-rust infection which exceeds in the aggregate an area of three-fourths inch in diameter.

Sooty blotch or fly speck which affects more than one-third of the surface.

(*g*) Insects.

More than five healed insect stings.

Worm holes.

Tolerances for Preceding Grades

In order to allow for variations incident to proper grading and handling, not more than a total of 10 percent of the apples in any container may be below the requirements of the grade, provided that not more than 5 percent shall be seriously damaged by insects and not more than one-fifth of this amount, or 1 percent, shall be allowed for decay or internal breakdown.

When applying the foregoing tolerances to the combination grades no part of any tolerance shall be used to reduce the percentage of apples of the higher grade required in the combination.

The tolerances specified for the various grades are placed on a container basis. However, any lot of apples shall be considered as meeting the requirements of a specified grade if the entire lot averages within the tolerances specified, provided that no sample from the containers in any lot is found to exceed the following amounts:

For a specified tolerance of 10 percent, not more than one and one-half times the tolerance shall be allowed in any one package.

For specified tolerances of 5 per cent or less, not more than double the tolerance shall be allowed in any one package.

Condition after Storage or Transit

Decay, scald, or other deterioration which may have developed on apples after they have been in storage or transit shall be considered as affecting condition and not the grade.

Size Requirements

The numerical count or the minimum size of the apples packed in a closed container shall be indicated on the package.

When the numerical count is marked on the container the apples shall not vary more than one-fourth inch in their transverse diameter.

When the numerical count is not shown the minimum size shall be plainly stamped, stenciled, or otherwise marked on the container in terms of whole inches, whole and half inches, whole and quarter inches, or whole and eighth inches, as 2½ inches minimum, 2¼ inches minimum, or 2⅝ inches minimum, in accordance with the facts. It is suggested that both minimum and maximum sizes be marked on the container, as 2¼ to 2¾ inches, or 2½ to 2¾ inches, as such marking is especially desirable for apples marketed in the export trade.

"Size" means the transverse diameter of the apple taken at right angles to a line running from the stem to the blossom end.

In order to allow for variations incident to proper sizing, not more than 5 percent of the apples in any container may not meet the size requirements, provided that when the maximum and minimum sizes are both stated an additional 10 percent tolerance is provided for apples which are larger than the maximum size stated.

Packing Requirements

Each package shall be packed so that the apples in the shown face shall be reasonably representative in size, color, and quality of the contents of the package.

Boxes. Apples packed in the standard northwestern apple boxes shall be arranged in the containers according to the approved and recognized methods with the stems pointing toward the ends of the boxes, except when jumbled, and all packages shall be well filled but the contents shall not show excessive or unnecessary bruising because of overfilled packages. Apples packed in the standard northwestern apple boxes shall show a total bulge (top and bottom) of not less than three-fourths inch. Each wrapped apple shall be completely enclosed by its individual wrapper.

Baskets. Apples packed in round-stave bushel baskets or tubs shall be ring faced and tightly packed with sufficient bulge to prevent any appreciable movement of the apples within the containers when lidded.

Barrels. Apples in barrels shall be tightly packed.

In order to allow for variations incident to proper packing not more than 5 percent of the containers in any lot may not meet these requirements.

Marking

In order to conserve space, abbreviations may be used for marking the United States grade names on containers. The following abbreviations are suggested where it is not desired to use the full grade name:

1. U. S. Fcy. for U. S. Fancy.
2. U. S. No. 1 for U. S. Number 1.
3. U. S. Com. for U. S. Commercial.
4. U. S. Util. for U. S. Utility.
5. Combination grades may be designated by abbreviations of the grades preceded by the abbreviation "Comb." as "Comb. U. S. Fcy.—U. S. No. 1."

Standards for Export

As applied to condition factors.

1. The apples in any lot shall be generally tightly packed when in barrels or baskets and either generally fairly tight or tightly packed when in boxes.

2. Not more than 5 per cent of the apples in any container shall be further advanced in maturity than firm ripe.

3. Not more than a total of 5 percent of the apples in any container shall be damaged by bitter pit, Jonathan spot, scald, internal breakdown, water core, freezing, decay, or other condition factors, except that—

(*a*) Not more than 2 percent shall be allowed for apples affected by decay.

(*b*) Not more than 2 percent shall be allowed for damage by internal breakdown.

(*c*) The apples shall be free from scald unless they are properly packed in oiled paper or have been especially treated with oil to prevent scald. When so packed or treated, not more than 2 percent of slight scald shall be permitted.

Any lot of apples shall be considered as meeting the standards for export if the entire lot averages within the requirements specified, provided that no sample from the containers in any lot is found to exceed double the percentages specified.

Secure Service and Regulatory Announcements No. 16 from the United States Department of Agriculture.

II. U. S. STANDARD CONTAINERS

The U. S. Standard barrel contains 7056 cubic inches. Subdivisions of this barrel are three-fourths barrel, one-half barrel, and one-third barrel. The standard barrel, commonly called a 3-bushel barrel, actually holds 3 bushels and 9 quarts. Many states have enacted as state laws the United States standard barrel act.

The cranberry barrel contains 5826 cubic inches.

Climax baskets are of three sizes holding 2, 4, or 12 quarts dry measure.

Berry boxes and till baskets contain one-half pint, one pint, one quart, and multiples of the quart, all dry measure. The dry quart holds 67.2 cubic inches.

Hampers and round-stave baskets are of the following capacities: ⅛, ¼, ½, ⅝, and ¾ bushel, 1 bushel, 1¼, 1½, and 2 bushels. A bushel, standard dry measure, holds 2150.42 cubic inches. This is the Winchester "struck" bushel.

Many states have attempted to define the bushel in terms of weight. But the bushel is a unit of volume, and it is impossible to define accurately a unit of volume in terms of weight, as the weight of any given volume of fruits or vegetables will vary with the size, variety, and condition of the product, and the tightness of the pack.

Standard splint baskets are of the following capacities: 4, 8, 12, 16, 24, and 32 quarts, dry measure.

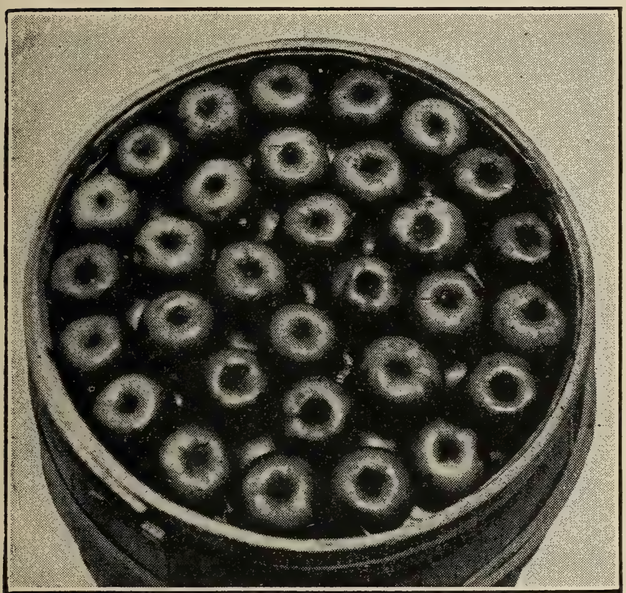
III. PACKING APPLES IN BARRELS

The fruit may be packed from a packing table or from compartments into which the fruit runs from sizing machines.

(1) Preparing the barrel: Drive down quarter hoops and fasten with three or four three-penny nails well clinched inside of barrel. Take out one head, the better of the two, removing the top hoop. The cooper marks the last head he puts in the barrel. This is always the better head, with the best croze or groove, in which the beveled edges of the headpieces fit. Nail the other head, using about six four-penny nails driven through the hoop, into the headpieces at an angle of about 45 degrees. Nails driven straight down will not hold as well and will often break the hoops when the barrels are opened for inspection. Nail head liners (small strips of hoops or other woods moistened to make them flexible) across edges of head pieces to prevent their pushing out when the barrel is packed. The second hoops should never be nailed. Mark the head with the proper terms giving variety, grade, size, and packer's number. Some packers merely indicate the essential facts with a pencil and complete the label later. Rubber stamps or stencils are commonly used for marking the package. Much of the information, excepting the name of the variety and the size, may be put on the head of the barrel at odd times before the packing season begins. The use of barrels with hoops of different colors for the different grades will help to avoid mistakes.

(2) Facing the barrel: Place a corrugated paper pad, with corru-

gated side down, in the barrel. Sorters have been selecting "facers" from the table and placing them in sidepockets on the table or in drop-handle baskets hung by hooks on the sides of the table. These "facers" are the apples that are to form the first layer or plate in the barrel. They should be fairly representative of the whole barrel, and uniform as to size and color in order to fit well and to make the face look as attractive as possible when the barrel is opened (Figs. 51 and 52).



(*N. Y. State College of Agr.*)

FIG. 51. A well-arranged face.

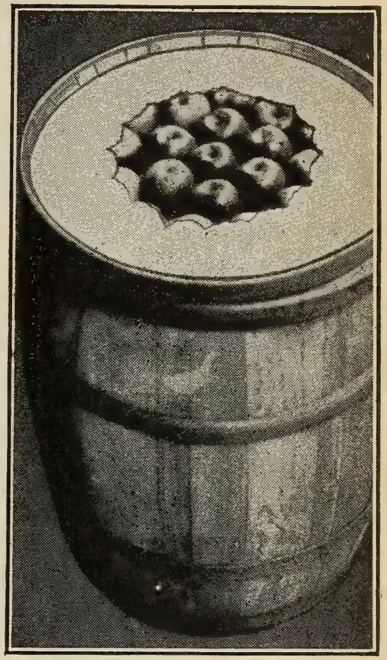


FIG. 52. A circle of lace paper is sometimes used to advantage for a high-class trade.

Turn the fruit carefully out of the basket into the barrel and then, with head and shoulders inside the barrel, turn the apples stem downward, placing them in circles or rings beginning at the outside. If apples are properly selected, the center of the face will be filled with one, three, or four apples, depending on the size of the fruit being packed, of the same size as or a trifle larger than those in the adjacent ring. The face should never be completed by an apple much larger or smaller than the others in the face. If this is necessary, it indicates that apples of the proper size or uniformity were not selected. The face should be tight and springy when completed. Use the same number of apples for the face in every barrel of the same variety and grade, so that the appearance is the same no matter what barrel may be opened for inspection.

Devices are now available for arranging the face before placing the fruit in the barrel and are used by some growers. The packer inserts the device in the barrel and releases the fruit when it is in place.

(3) Filling the barrel: "Spotters" or backers are now placed with colored cheek down over the spaces between the facers, insuring a very attractive appearance when the barrel is opened for inspection, and keeping the face in place until the barrel is packed.

Fill the barrel, running in about one-half bushel of apples at a time either from compartments of the packing table or from baskets, carefully turned into the barrel. If apples are run into the barrel from the table, use a canvas or burlap apron attached below the gate so that the fruit may be lowered gently into the barrel. Rack or shake the barrel quickly and sharply, to settle the fruit into place. Do this regularly when filling the barrel. No amount of pressing after the barrel is filled is a substitute for racking, and a slack barrel will result after the fruit has been packed for a short time. Some growers and associations have devised mechanical shakers which work well.

Shredded oiled paper should be added to barrels that are intended for storage, especially for those varieties particularly subject to scald. (See page 66.)

(4) Tailing and heading the barrel: When the barrel lacks about 3 inches of being full, it is ready for "tailing" in preparation for closing the package. Tailing may consist merely of placing the apples as evenly as possible without special arrangement, or the barrel may be "ring tailed," improving the appearance and facilitating the insertion of the head. In ring tailing, the packer should quickly arrange the fruit in the last two or three layers so as to insure a fairly even surface. A follower consisting of a 2-inch plank cut to fit into the barrel, heavily padded on the lower side, with a handle on the upper side, should be used in connection with racking the barrel to secure this even surface. In fact a follower should be used in packing regardless of the form of tailing that is practiced. It will level off the pack and insure a distribution of the pressure of the head uniformly over the fruit.

In ring tailing, place the last layer of fruit on its side or cheek in concentric rings with the stem of one apple next to the blossom end of its neighbor. The center of the tail should be a little higher than the rest, but the fruit should project very slightly, if at all, above the staves in a well-packed barrel. For export trade fill the barrels a little higher than for domestic markets. Rack them thoroughly on a solid base while filling.

Put on a corrugated paper pad, with the smooth side against the fruit, place head pieces and top hoop on the barrel, and attach the press, or roll the barrel on the platform, if one is used in connection with the press.

Two types of presses are in common use, the screw and lever. Press the head slowly into place, driving down the top hoop as the head settles into the croze or groove in the staves. Nail the head as before, four properly driven nails being sufficient. For greater safety, use head liners. The package should always be handled very carefully after it has been packed.

(5) Packing tables: The packing table may be a fixed piece of equipment in the shed or packing house, or portable tables may be used. A good portable packing table, which will hold several barrels, provides a slatted bottom, beveled on the upper edges, permits refuse to drop out, the pitch from the back to front makes it easy to work the apples toward the barrel, and yet they move deliberately enough to permit careful inspection and to prevent injury. Padded baskets, hung on the sides of the table, may be used for facers.

A board or hinged device closes the lower end or gate through which fruit passes to the barrel. The barrel should stand on a hardwood plank or concrete for "racking down." A canvas or burlap apron extends from under the gate end of the table out over the barrel, so that the apples may be lowered gently into the barrel.

Such a table may have chutes or places for filling two barrels at once and is often mounted on wheels at the back to facilitate movement from place to place. Specifications of a good table follow:

> Table 8 feet by 4 feet with 8-inch sides, slats in bottom 1 inch square with beveled upper edges and spaced 1 inch apart, legs 2 inches by 4 inches or 2 inches by 6 inches, lower legs 38 inches long, upper legs 44 inches long; opening or gate over barrel 8 inches wide—material soft pine or other dressed lumber. The length may be increased to permit handling fruit by a larger number of workmen, but the table should always be narrow enough so that a sorter standing at either side may reach beyond the center. Sides should be padded as well as the upper 2 or 3 feet where the apples are turned onto the table. Chutes for culls may be built in.

A grower with 1000 or more barrels to pack would probably find a mechanical sizer a good investment, yielding better results than running the fruit over a packing table.

Some tender varieties as McIntosh or Northern Spy should probably not be run over a packing table, but should be sorted from long tables with canvas bottoms in order to avoid bruising. In fact, such varieties should not be packed in barrels.

IV. MODIFIED ATMOSPHERE STORAGE FOR APPLES AND PEARS

As Described by the Department of Pomology, Cornell University

What Is Modified-Atmosphere Storage? Fruits are living organisms which carry on the fundamental chemical reaction of respiration. Carbohydrates are oxidized in the presence of oxygen with the subsequent production of water, carbon dioxide, and heat. In addition to the thermal effect, any chemical reaction is affected by a diminution in amount of one of the reactants or by allowing one of the end products to accumulate. Hence respiration is diminished in intensity not only by lowering the temperature (as in cold storage) but also by reducing the amount of oxygen or allowing the carbon dioxide to accumulate.

By use of gas-tight structures and controlled ventilation, the desired proportions of carbon dioxide and oxygen can be easily attained in most cases. For example, suppose that an operator desires an atmosphere containing 10 percent carbon dioxide and 11 percent oxygen. The respiring fruit in a gas-tight, metal-lined storage chamber produces an accumulation of carbon dioxide which finally reaches the desired 10 percent value. By difference from the normal air figure of 21 percent oxygen, the oxygen value will now be 11 percent, since during the production of carbon dioxide almost an equal volume of oxygen has been consumed. In such a system, frequent determinations of the carbon dioxide are made on a katharometer outside the chamber, and if the carbon dioxide exceeds 10 percent, a port in the door is opened until the proper percentage has been attained.

With some varieties it may be desirable to have independent control of carbon dioxide and oxygen. Control of these two gases by regulated ventilation will provide the desired atmosphere only when the summation of these two gases is 21 percent. For an atmosphere such as 5 percent carbon dioxide and 2 percent oxygen, the oxygen is reduced, by respiration, from the normal figure of 21 percent down to 2 percent, and the excess carbon dioxide is absorbed by means of sodium hydroxide or calcium hydroxide in an atmospheric "scrubber." The oxygen is prevented from falling below 2 percent by ventilation as required.

The maximum temperature employed with any variety of apples is 40° F. This requires insulation and refrigeration equipment just as with cold storage. Modified atmosphere storage should be regarded as a supplement to cold storage.

Advantages of This Type of Storage. The following advantages are to be realized in the use of this system:

1. Many varieties of apples are subject to low-temperature troubles such as brown heart, internal browning, and brown core. By using temperatures from 38 to 40° F. and the proper atmosphere, these varieties can be kept just as long as if not longer than at 32° and will be free from these disorders.

2. With some apple and pear varieties, temperatures as low as 34° F. can be employed and storage life is very greatly lengthened. For example, Kidd and West have shown that Bartlett pears normally can be kept about eight weeks in cold storage at 34° F. In modified atmosphere storage they can be kept satisfactorily seven months at 34° F.

3. A specific effect of carbon dioxide is greatly to retard the normal green to yellow change in apples and pears. This is of great importance in storage of varieties of green cooking apples.

4. A marked residual effect of storage is noticed as a result of this scheme. Fruit removed from storage will remain marketable *much* longer than that removed from cold storage.

5. Because of the inhibitory effect of carbon dioxide on mold growth, somewhat higher humidities can be used in modified atmosphere storage than in cold storage. This means less fruit shriveling during storage.

Disadvantages of This Type of Storage. 1. Because of the danger of suffocation and of loss of the required atmospheric concentrations of carbon dioxide and oxygen, operators cannot enter the chambers for inspection of the fruit or manipulation of equipment. Hence, fruit is periodically examined by reaching through the ventilating port. Since the chamber cannot be opened until the storage season is over, the fruit to be marketed in each marketing period is put in separate chambers.

2. It is difficult to construct buildings gas tight. In spite of the sheet-metal linings and vaseline-sealed joints, in even the best-constructed modified atmosphere storages, there is a leakage of 6 percent per day, or more.

3. As has been stated, modified-atmosphere storage is not universally applicable to all fruits or all varieties of any one fruit.

4. The double effect of low temperatures plus atmospheric control cannot always be expected to give the full theoretical benefit that might

be anticipated. With certain varieties, concentrations of carbon dioxide as low as 2 percent are toxic at a temperature of 32° F. Because of this toxicity factor, with many varieties of fruit the temperature must be as high as 40° F. Different apple varieties have different specific atmospheric and temperature requirements for long-time keeping. This necessitates the use of different chambers with varieties of different atmospheric requirements.

5. With apples the scald hazard is increased because of the restricted ventilation. For this reason, all apples stored in gas-tight chambers must be treated with oiled papers.

Applications of Modified-Atmosphere Storage. At Cornell the only apple varieties studied in detail to date are McIntosh, Cortland, and Northwestern Greening. Of these three, Cortland is the only one which has not offered real promise in modified-atmosphere storage. The scald hazard is so great with this variety even with oiled papers in the container that it is not recommended for trial in this system of storage till a better method of scald control is found. Preliminary work indicates that there may be such a control. With both McIntosh and Northwestern Greening the best atmospheres have proved to be 5 percent carbon dioxide and 2 percent oxygen, with a temperature of 40° F. Of course, the remainder of the atmosphere was nitrogen. To attain such an atmosphere, it is necessary to reduce the carbon dioxide concentrations with an atmospheric scrubber or washer which contains sodium hydroxide solution. Such a system is in use with certain varieties in England.

Pears seem eminently adapted to this type of storage, according to studies in England and California. Just what are the *best* atmospheres for our American-grown varieties for longest keeping is not clear. None of the stone fruits seems adapted to long-time storage in modified atmospheres, it would seem from California investigations.

V. FROZEN FRUIT

Freezing methods of fruit preservation make it possible for a housewife to serve a wide variety of fruits with fresh qualities on very short notice at any season of the year. Frozen fruit may be purchased for less than out-of-season fresh produce of equal quality. Consequently a large industry has been built up which caters to the discriminating housewife, confectioner, and dining room.

To produce a good frozen product, it is important to select fruit of proper quality and maturity, and in many cases the proper variety. Klondike, Blakemore, Marshall, and Dunlap strawberries; Eclipse, Elberta, and South Haven peaches; Cuthbert raspberries; Monitor, Damson, Italian Prune, and Yellow Egg plums have qualities which make a better frozen product than other varieties of the same type of fruit.

Cranberries, blueberries, raspberries, and plums are usually frozen whole; strawberries and peaches are packed both whole and sliced; apples, cranberries, cherries, and grapes may be frozen whole or converted into juice which is held fresh for over a year.

Although the freezing of berries in syrup at 10° F. and packing in kegs and cans have been practiced since 1900 and about 70,000 barrels of strawberries and raspberries are still packed in the Pacific Northwest each year, fruit is now made available in tight rectangular cartons or paraffined cardboard. Commercial companies have taken advantage of research carried out by the Bureau of Plant Industry at the University of California and the Georgia Experimental Station. Since a large proportion of the fruit is eaten raw, they have shown that it is important to prevent shrinkage, to maintain the flavor, to reduce oxidation, and thereby to preserve the natural color of the raw fruit.

Various companies differ in the pre-treatments, the minimum temperatures, and the rates of application of temperatures which they use to produce their particular product. Sharp freezing in fruit chambers at 0° F., spraying a cold liquid over fresh fruit, moving it through a cylinder where the air is blown toward it, and placing it in contact with plates at 40° F. are four of the most common freezing methods. After the fruit is frozen the finished product must be stored in a freezing temperature. Facilities for marketing of this product have become very efficient during the last few years.

Some growers have found it to their advantage to adapt a portion of their apple cold storage to freeze surplus fruit in heavy-crop years. This practice of freezing fruit in the home storage stabilizes the market and is a new outlet for produce. In 1938, in New York State, 22 million pounds of sour cherries were frozen. Many strawberries are "cold packed" in North Carolina, Maryland, Louisiana, and Tennessee; cherries in Michigan and New York; cranberries in Massachusetts; and other fruits in smaller quantities in limited sections where they are grown.

In most fruit districts the large cold-storage plants have freezing lockers which they rent to growers for their own use for as little as $8.00 a year. In these a large part of the year's supply of various products may be kept for family use. Some growers install their own lockers. Lockers are available on the community basis in some sections.

COMMUNITY STUDIES

Make a survey of the practices of the growers in your community as follows. Do this for each fruit of commercial importance.

1. Varieties grown in order of importance.
2. Average picking dates or order of picking.
3. Kinds of ladders used—reasons for selection, where obtained, and cost.
4. Kinds of picking receptacles—reasons for use, where obtained, cost.
5. How fruit is picked—by day, by package—quantity picked in day by each method—wages and rates paid.
6. Yields per tree and per acre—make estimate and then check with actual yields.
7. How fruit is handled after picking—in orchard, in crates or barrels or other packages and hauled under cover.
8. Is crop packed? If not, how handled?
9. If packed, how soon after picking?
10. What package is used? Why? Cost of package?
11. How many packages packed in day? Cost of packing?
12. What is the proportion of fruit that packs into various grades? What disposition is made of fruit not packed?
13. How is fruit held after packing?
14. How and to whom is fruit sold? Prices received?
15. Make sketch of a packing house, and indicate improvements in lighting, arrangement of equipment, rapidity of handling, and storage.
16. Study the operation of a roadside stand, with reference to location to invite patronage, attractiveness and convenience, first cost, cost of attendant at stand, number of days operated during the season, kinds and grades of fruit desired by patrons, average daily and seasonal sales.
17. Study the methods of construction, loading, and refrigeration of a refrigerator car.
18. Study the United States grades for packing apples and peaches and the packing and branding requirements of your own state, if any.

B. Make a survey of the storage facilities of your community. Begin with the ordinary cellar storage. Follow with the special fruit cellar and storage building, and finish with a cold-storage plant.

Investigate:

1. Location:
    - *a.* Ease of access to orchard and with team or truck.
    - *b.* Access to shipping point.
2. Facilities for unloading

3. Capacity.
4. Construction:
    a. Walls.
    b. Floor and ceiling.
    c. Attic and auxiliary room if any.
5. Ventilation provisions.
6. Humidity provisions.
7. Cost.
8. Cost of storing by month and season.
9. Get operator's plan for securing and maintaining desired temperatures.

CHAPTER II

PREPARING FOR WINTER AND DETERMINING INJURY FROM COLD WEATHER

As the grower works with the fruit plantation during the summer, he is making note of things that should be done before winter comes.

Operations:

1. List trees to be replaced.
2. Provide soil drainage.
3. Control mice.
4. Protect trees from mice and rabbits.
5. Determine injury from cold weather.

1. List Trees to Be Replaced. Trees die from various causes and must be replaced, or they may be so weak as to make replanting advisable. It is a good practice for the grower to look for such trees as he goes through the orchard during the summer. If he waits until the leaves are off, he may fail to detect them. He should make a record of the varieties and the number of each that must be replaced and order them in the fall, even though delivery may not be desired until spring. Growers sometimes become careless with regard to filling vacant spaces with trees. Since the land is devoted to the fruit enterprise and since orchard operations must go on even though some trees are missing, it is poor business to have only a partial stand of trees.

2. Provide Soil Drainage. Some young trees may stand in depressions that are settling points for surface water. If left thus through the cold period, they may suffer from killing of the roots or trunk near the base of the tree. The depression should be filled so that the water drains away from, rather than toward, the tree.

The area in general may be so flat as to possess poor surface drainage. The condition is aggravated if the subsoil is heavy and slow in permitting water to work through it. Under such conditions, a system of soil management that will ridge up the tree rows, so that the water runs to the center of the spaces between the rows, will help the trees through the winter. Young trees located on such areas should never be left in dead furrows or out furrows during the winter. All tile drains should be inspected in the fall to make sure that they are working properly and that the outlets are in good condition.

3. Control Mice. Mice often damage fruit trees by girdling them above or below ground. Usually they are more destructive in orchards under the sod or mulch systems with a heavy stand of crops, especially if the crop has gone to seed and thus attracts them. The injury, though greatest in the winter months, is likely to take place any time in the fall or even early in the growing season.

Injury above ground is usually caused by the common field or meadow mouse, that below ground by the pine mouse. The field mouse is larger and grayer than the pine mouse, which is reddish brown and resembles the mole. The grower is not likely to note the damage to the tree by the pine mouse until it is too late to prevent it.

Poisoning the mice is practicable, especially when the orchard cannot be cultivated. In using a toxic bait or rodenticide the grower should take advantage of his knowledge of the habits of the tree-girdling mouse. This mouse confines its movements to small runways which can easily be found by lifting the mulch under the trees. If a bait is placed directly in the paths and covered, it is almost certain that good results will be obtained. Do not place bait where no runways are to be found. To prepare bait, cut cull apples of a firm variety into ½-inch pieces, 100 pieces making approximately a quart of material, and sift over it a white powder which can be obtained for a small cost from the United States Biological Survey, Washington, D. C. This bait must be used on the day it is prepared.

One piece of bait is sufficient for every 10 square feet of orchard cover, both under and between the trees, and out to 100 feet on every side of the field. The bait must always be covered. It is effective in 24 hours. This treatment should be made in late fall after all apples are picked up. Although the apple cubes make a very good bait and conveniently decay after a few days' exposure, a mixture of grain may be used instead if there are many windfall apples left under the tree. One treatment a year is satisfactory, provided that no new mice come in from outside of the orchard. If the orchard is surrounded by hedgerows, stone walls, etc., it may be advisable to treat the outer two or three rows several times.

4. **Protect Trees from Mice and Rabbits.** Grass, litter, and trash of all kinds should be hoed away from the base of young trees before winter comes. Mice seldom molest trees not in sod, if they must come out into the open to do so.

If a mound of clean soil is hoed up about the base of the trees and thoroughly packed down, this in itself is a good insurance against injury by mice and is the only treatment given by many fruit growers. It may not be sufficient, however, for sod orchards or for outside rows in cultivated orchards surrounded by meadows or hedgerows. Mice sometimes do damage under such conditions even during the growing season, especially in the fall.

Protection then best takes the form of some material wrapped about the base of the trees and shoved down into the soil so that there is no vulnerable spot above ground. Tar paper is effective, but should be removed each spring as there is sometimes evidence of injury to the bark when it is allowed to remain. The continued repetition of this operation makes the practice an expensive one. Wood veneer strips are also used, and even newspapers or building paper are quite effective.

Hardware cloth with two to four meshes per inch (Fig. 53) will give protection against meadow mice during the summer and autumn. At no time is it protection against the pine mouse. This cloth comes in rolls 36 inches wide. The roll may be cut in two at the center, making each strip 18 inches wide. Cut these strips into pieces at about 14-inch intervals so that pieces 14 by 18 inches are obtained. Roll and bend the strip about the trunk in such manner that the long way is up and down the trunk, and that the edges overlap well. The lower edges should be pushed well down into the soil. Twist a small wire loosely about the center.

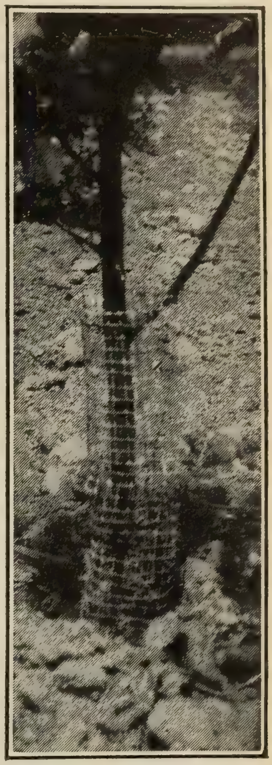


Fig. 53. Wire protectors will usually prevent injury from mice. They should be pushed into the soil and the cut edges at the top should be bent away from the tree.

The trees are thus protected for several years without further attention, and at one operation. When the diameter of the trunk makes a change necessary, the strip may be turned so that it is 14 inches high and 18 inches in circumference, if desired. The objection to the use of this material lies in its first cost, but once obtained it will last for many years and may be transferred to younger trees as older ones outgrow the need for it.

The foregoing measures also constitute protection against the common wild rabbit. In addition, repellents, such as lime-sulfur at full strength with various materials added, are sometimes applied with a brush to the tree trunks. These possess value but need to be renewed frequently and sometimes are not sufficient. A repellent wash for rabbits recommended by the United States Department of Agriculture is:

Fish oil	1/3
Concentrated lime-sulfur	1/3
Water	1/3

Mix the materials thoroughly, and paint the tree from the ground well up on the scaffold branches. After each heavy snowfall pack down the snow about the tree trunks, so that mice will not burrow beneath or rabbits work over the top of the snow to damage the trunk or branches.

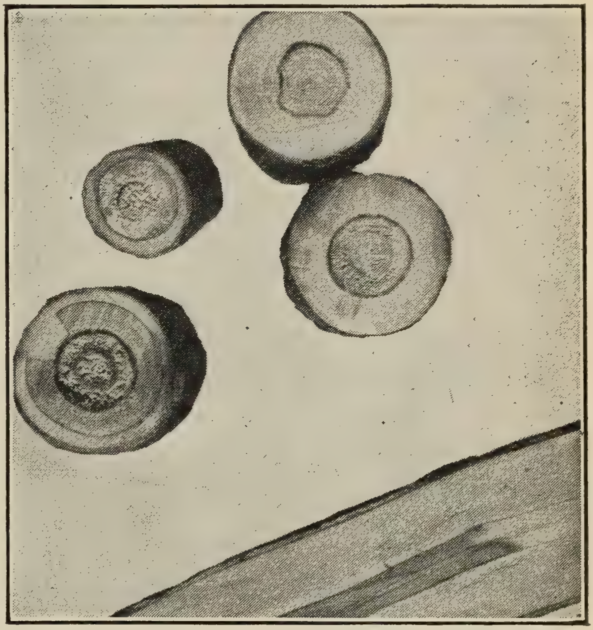
Fig. 54. Trees grown in sod or under a mulching system are especially liable to injury from mice. This tree was girdled when the snow was on the ground. The white cloth separates the original trunk and the bridge graft on the right.

If clippings are made from the branches in late fall and strewn on the ground away from the trees, mice and rabbits will often feed on them without disturbing the trees.

The jack rabbit, a famous jumper, also able to stand on its hind legs and reach several feet in the air, constitutes a real problem in fruit sections where it is found. Fencing has been tried with only partial success, and it is expensive. A dog, gun, and restrictive laws are better measures. The same holds true of deer, which have done very great damage to young orchards in some sections.

Trees not more than three years of age may usually best be replaced, if girdled completely by mice or rabbits. Older trees may be bridge grafted (Fig. 54) with a considerable measure of success as described in the chapter "Propagating Fruit Plants." Areas from which the cambium has been removed only in part may be painted with white lead and oil or coated with wax.

5. Determine Injury from Cold Weather. Although many different factors affect the distribution of the fruit industry, probably the greatest single factor has been winter temperatures. Minimum temperatures in different sections of the country have determined the kinds of fruit that can be grown in such sections. In addition, an occasional winter of unusually low temperatures is experienced in a section where certain fruits normally thrive and a large portion of the trees are seriously injured or killed, causing large financial losses. Injury occurs to various parts of the tree such as: (*a*) wood tissues, (*b*) leaf and fruit buds, (*c*) blossoms, (*d*) roots.



(*Mich. Exp. Station*)

FIG. 55. Cross and longitudinal sections of apple wood showing "black heart" injury.

(*a*) *Injury of Wood Tissues.* The different tissues within the same plant vary considerably in their responses to low temperatures. In well-hardened wood, pith is usually the least-resistant tissue, followed in order by sap wood, bark, and finally cambium, which is usually the most resistant.

Wood injury occurs in many different forms such as: (1) black heart, (2) crotch injury, (3) crown or collar injury, (4) sun scald, (5) splitting of the trunk, and (6) killing back of the twigs and young branches.

(a) (b) (c) (*Indiana Exp. Station*)

Fig. 56. Crotch, limb, and trunk injury. (*a*) Crotch and trunk injury from cold weather. Note distinct line of demarcation between dead and live tissues. (*b*) This tree had two limbs girdled by winter injury. Crotch and trunk injury has also occurred. The girdled limbs have been cut off close to the main branch and the dead bark has been removed from the other injured areas in preparation for painting. (*c*) Same tree as *b*, with injured areas properly painted for protection.

When injury to wood tissues has occurred, the affected tissues usually become brown or black in color. The injury can readily be noted either by cutting off small branches, by cutting through the bark of the branches, or by splitting small branches. Figure 55 represents this type of injury.

(*Mich. Exp. Station*)

Fig. 57. Collar injury from low temperatures at the base of an old apple tree. Note that the injury has occurred on the seedling stock just below the graft. The top is McIntosh.

When injury occurs in the crotch of the tree or at the ground or collar, the bark usually is killed and gradually loosens and comes off. Such injuries are shown in Figs. 56 and 57.

Injuries on the trunk, often on the south and southwest sides, may develop if sudden changes of temperatures have occurred during the days and nights of winter.

Occasionally the twigs and young branches of fruit trees are killed during severe winters. Apricots and peaches are

(*Indiana Exp. Station*)
FIG. 58. Ten-year old Stayman Winesap apple tree with sparse summer foliage as a result of winter injury.

usually less resistant to low temperatures than apples and some species of plums. Cherries and the Japanese plums are usually intermediate between these other fruits in their resistance to low temperatures.

When the branches of young apple trees are injured by cold weather, the foliage is usually weak and sparse the following spring. This condition is shown in Fig. 58.

(*b*) *Killing of Leaf and Fruit Buds.* Killing of leaf buds is not a very common occurrence in fruit trees, unless the whole twig is killed back. However, fruit buds of such fruits as peaches, cherries, Japanese plums, and apricots are often killed by low temperatures. This injury can be determined by cutting the buds longitudinally. The injured buds will usually have a black center and the damaged flower parts will be easily seen.

(*c*) *Killing of Blossoms.* Great losses are occasionally incurred in fruit sections as a result of freezing temperatures at blossoming time. The resistance of the blossoms to cold is generally greater when they are quite small and before the petals open. This resistance decreases as the petals open and continues to decrease until the small fruits form. The blossoms of peaches, plums, cherries, and apricots, which open comparatively early, especially if a warm spell occurs early in the spring, are among those most often killed.

(*d*) *Killing of Roots.* The roots of fruit trees are usually much more tender than the tissues above ground. As a result, tree roots may be killed when the portions of tree above ground are uninjured. The internal tissues of injured roots turn brown or black. Injury is generally worse in light, sandy soils because such soils are usually drier, fluctuate more widely in temperature, and become colder than the heavier and more moist soils. If the trees are on hilly, wind-swept locations where the snow is likely to be blown away, more root injury usually occurs.

The use of cover crops or sod is valuable in helping to prevent root injury.

GENERAL INFORMATION

I. Necessity of Maturing and Hardening of Wood Tissues

Growing and immature tissues are injured at much higher temperatures than dormant tissue. Most trees which have been caused to grow late in the fall by certain weather conditions or by certain cultural practices, such as heavy fertilization and pruning and late soil cultivation, are less resistant to low temperatures than trees which stop growth earlier in the season. This is especially true of young trees, although the difference is not so marked in young peaches.

Apparently an accumulation of carbohydrates in the tissues is one thing which is associated with maturity, and such trees appear to be better able to withstand low temperatures. In young trees which grow vigorously late in the season, and are often severely injured, most of the carbohydrates apparenly are used in growth so that the accumulation of these materials in the tissues is comparatively small.

Trees which lose their foliage early in the summer because of the lack of proper spraying are usually injured more severely than similar trees which carry healthy foliage throughout the season.

Growth of the trees should be checked in late summer and the wood allowed to mature. The use of vigorously growing cover crops which will compete with the trees late in the season for moisture and nitrates will assist greatly in checking growth and bringing about this desirable condition.

COMMUNITY STUDIES

1. After severe winters, make a survey of the winter injury in your section. Determine:

    a. The kinds of fruit injured.
    b. The relative resistance of the different fruits.
    c. The relative resistance of different varieties of the same fruit.
    d. The different types of injury.

2. Were some orchards injured more than others? Determine the reason if possible.

3. Was the injury worse with vigorous or weak trees?

4. If frosts or freezes occur at blossoming time, keep a record of the temperatures and determine the percentage of injury of the blossoms of several varieties by examining the pistils.

5. Make a list of the varieties of the different tree fruits, and arrange it in order of the smallest percentage of injury to blossoms.

6. If the wood has been injured and the buds of peach trees have been killed, arrange an experiment to determine the effects of different amounts of pruning and of nitrate of soda on the subsequent recovery of the trees.

CHAPTER III

ESTABLISHING THE ORCHARD

A mistake in establishing the orchard is much more serious than in the case of annual crops, where the error may be repaired at the close of a single season. Careful planning and preparation for an orchard over a reasonable period of time will pay large dividends.

Operations:

1. Selecting the region.
2. Determining the size of the enterprise.
3. Selecting the land to be planted.
4. Determining time of planting.
5. Determining varieties to plant.
6. Determining planting distances and planting plans.
7. Purchasing trees.
8. Caring for trees on arrival.
9. Preparing field for planting.
10. Planting the trees.

1. Selecting the Region. One of the first things that the prospective grower must do is to decide upon the region in which he will carry on his fruit enterprise. Certain areas have come to be known as favorable to this type of agriculture. The answer then is to look about you. The best source of information available about fruit growing is often from those who are growing fruit successfully. If none such are to be found in the region, then there is generally a good reason for it, because the region either is poorly adapted to the fruit enterprise or is better adapted to some other.

Of course, new transportation facilities may open up undeveloped areas. These new facilities may be railroads or waterways or truck routes. Competing lines frequently bring better service and lower transportation costs than a single line. The advent of the motor truck has done much to extend the fringes of commercial fruit growing away from the concentrated centers of the industry and within trucking distance of towns not well supplied heretofore with good fruit. Many such places often pay better prices (so long as the business is not overdone) than can be obtained on the general market.

Recognized and long-established fruit sections come to be known as such and enjoy a certain reputation and standing in the fruit world. Buyers are accustomed to look to them for their requirements. Interest in improved practices runs high. Each neighbor is always a possible source of new information and ideas. Savings on supplies and equipment are possible through combined purchases on a large scale; storage, transportation facilities, and outlets for by-products are likely to be good. Service from the recognized public agencies as the experimental stations, farm bureaus, and agricultural institutions will be largely proportioned to the net importance of the industry.

Consult Table 20 on transportation charges from producing to consuming centers on page 99.

Consult records of temperature and rainfall. Scab is more difficult to control in a very humid region. Codling moth flourishes in the presence of high temperatures and in sections where the rainfall is limited. It is more difficult to control in Niagara County, New York, with an average rainfall of 10 inches during May, June, July, and August than in the Hudson River Valley with 15 inches.

Temperature governs the geographical range. An increase in altitude may accomplish the same result as a change in latitude. Rainfall is a limiting factor in some sections. If lacking, it must be supplied by irrigation. Winter extremes of cold, or violent fluctuations in winter temperatures, even though the weather may be relatively mild as a whole, and long, hot summers are not the most desirable for deciduous fruits. Such fruits succeed well with an uninterrupted and definite period of winter rest, when life processes are reduced to a minimum.

Location near large bodies of water is often desirable, especially in the farther reaches of the industry, from the temperature standpoint. It is doubtful whether well-known

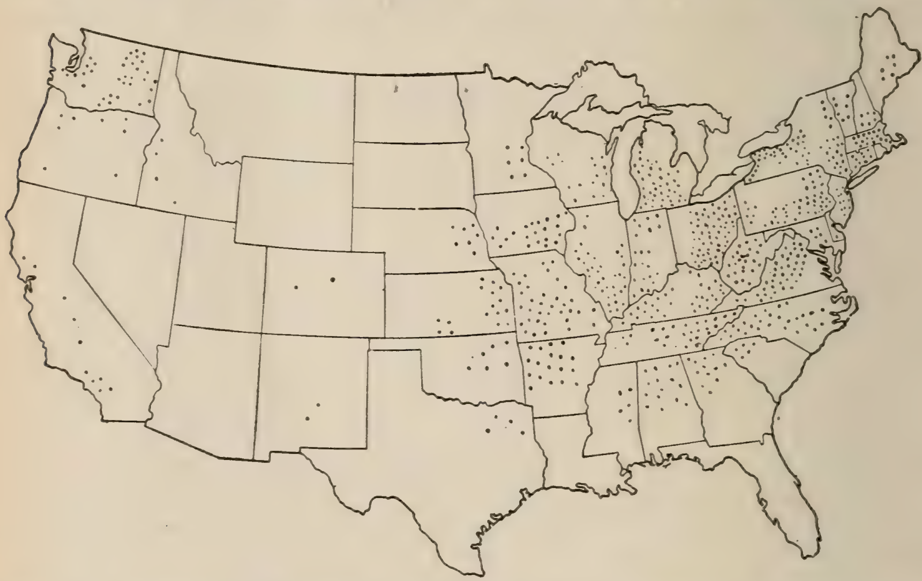


FIG. 59. Orchards of young apple trees are concentrated in the more favored sections.

fruit areas in Canada, New York, Ohio, and Michigan would have developed in the absence of Lakes Ontario, Erie, and Michigan. Such waters tend to retard spring growth beyond the date of frost injury, to extend the period for ripening and development in the fall, and reduce temperature fluctuations in the dormant period.

Table 31 gives the number of bearing and non-bearing apple trees in the various states for 1910, 1920, and 1935 and the totals for the United States. The total of bearing and non-bearing trees in 1935 was less than the total of bearing trees alone in 1920, but production has been maintained. This is due in part to better management and also to the fact that the apple industry is concentrating in the more-favored sections. Figure 59 indicates the sections of the United States in which the planting of young trees is greatest at the present time.

2. Determining the Size of the Enterprise. Before progressing beyond the point of selecting the region in which to grow fruit, the grower must decide upon the extent of the enterprise that he proposes to conduct.

Procedure:

(*a*) Consider market to be served.

(*b*) Consider supplemental farm enterprises.

(*a*) *Consider Market to Be Served.* This market may be the general market at large consuming centers, at a distance, or the local market near by. For the general market, the grower should have an enterprise that will enable him to ship

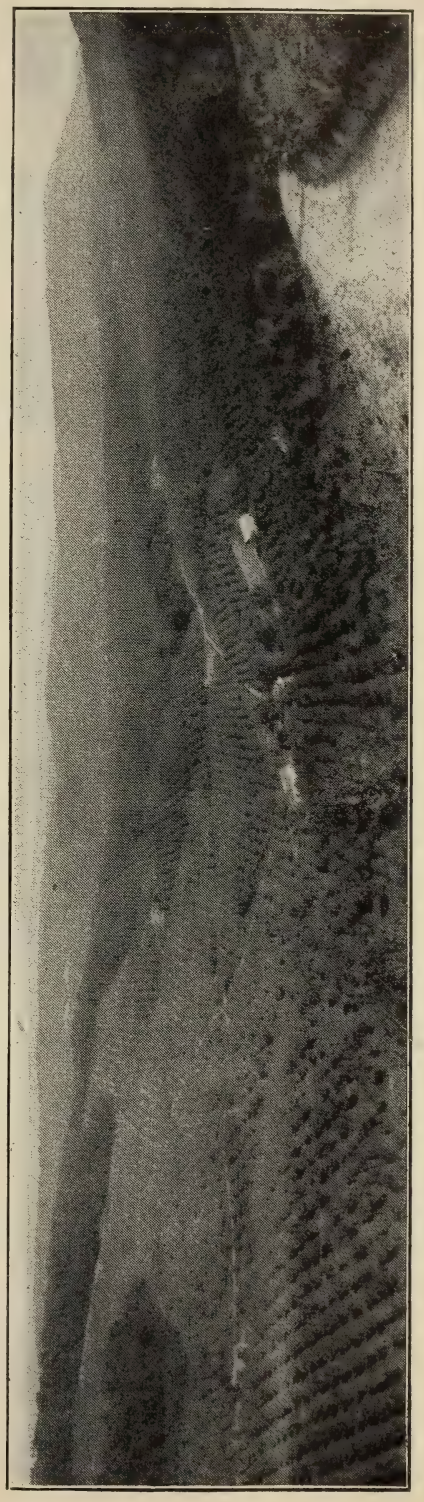


FIG. 60. A typical orchard setting on Tonoloway Ridge, Maryland, in the Shenandoah-Cumberland region. (*Hardie Mfg. Co.*)

TABLE 31

APPLES: NUMBER OF TREES BY STATES—U. S. BUREAU OF CENSUS REPORTS

State	Trees of Bearing Age			Trees Not of Bearing Age		
	1910	1920	1935	1910	1920	1935
Maine	3,476,616	2,833,304	1,064,528	1,045,123	512,217	152,541
New Hampshire	1,240,885	721,130	551,161	207,289	227,933	160,642
Vermont	1,183,529	712,594	492,824	219,833	254,029	182,189
Massachusetts	1,367,379	1,218,870	1,616,721	355,868	791,771	425,675
Rhode Island	152,009	173,110	178,594	54,560	71,375	36,941
Connecticut	798,734	692,569	788,703	211,839	266,405	213,906
New York	11,248,203	9,636,698	7,683,831	2,828,515	2,932,281	1,415,257
New Jersey	1,053,626	1,149,776	1,495,858	519,749	811,256	310,590
Pennsylvania	8,000,456	6,988,594	5,859,880	2,501,185	2,628,053	1,152,603
Ohio	8,504,886	5,970,410	5,263,237	2,438,246	2,047,687	1,431,839
Indiana	5,764,821	3,427,816	2,205,891	1,961,974	929,160	548,579
Illinois	9,900,627	5,113,063	3,949,228	2,548,301	1,825,886	905,701
Michigan	7,534,343	5,615,905	5,712,948	2,253,072	2,050,229	1,027,674
Wisconsin	2,430,232	2,321,860	1,862,107	1,408,726	825,258	383,431
Minnesota	1,380,396	1,596,264	1,118,518	1,571,816	637,187	153,293
Iowa	5,847,034	2,996,469	1,514,187	1,914,325	767,351	513,094
Missouri	14,359,673	5,162,859	2,975,691	3,624,833	1,585,823	859,870
North Dakota	15,941	26,157	22,365	70,023	19,694	6,112
South Dakota	274,862	255,637	126,884	460,547	136,082	18,042
Nebraska	2,937,178	961,313	592,374	967,133	401,788	181,168
Kansas	6,929,673	1,508,042	1,041,699	1,116,316	618,142	381,859
Delaware	429,753	816,109	722,956	263,813	308,487	53,748
Maryland	1,288,482	1,651,936	1,208,936	660,685	766,264	122,601
District of Columbia	1,654	1,036	1,309	29	1,178	15

Virginia	7,004,548	7,385,277	6,723,702	3,435,591	2,857,007	962,292
West Virginia	4,570,948	5,554,731	4,229,093	2,772,025	1,735,126	634,271
North Carolina	4,910,171	3,474,821	2,806,953	1,835,337	1,394,588	648,928
South Carolina	581,767	377,557	271,896	269,044	181,101	125,438
Georgia	1,878,209	1,515,505	1,128,316	822,327	806,731	292,227
Florida	8,180	493	3,031	5,968	1,490	2,936
Kentucky	5,538,267	3,742,936	2,574,944	2,106,297	1,427,408	789,019
Tennessee	4,838,922	3,181,659	1,949,504	2,117,246	1,032,490	647,890
Alabama	1,468,436	1,044,397	672,137	737,689	422,646	337,360
Mississippi	427,652	269,862	162,740	425,323	210,686	122,144
Arkansas	7,650,103	4,074,870	1,691,382	3,940,089	877,376	438,820
Louisiana	93,304	47,037	19,128	96,544	44,175	24,307
Oklahoma	2,955,810	1,417,911	534,786	2,060,384	428,502	154,100
Texas	1,138,852	468,027	160,932	1,127,573	236,485	91,572
Montana	696,753	1,059,198	351,683	1,308,066	69,328	16,050
Idaho	1,005,668	2,380,523	996,217	1,539,896	144,088	97,083
Wyoming	27,773	50,302	35,103	84,024	34,197	9,637
Colorado	1,688,425	1,777,737	814,411	1,972,914	183,315	56,013
New Mexico	542,528	687,799	385,919	914,254	167,097	55,417
Arizona	62,027	70,273	57,083	53,884	35,977	20,969
Utah	517,039	726,471	384,511	789,260	80,304	61,656
Nevada	74,454	42,612	37,150	16,868	9,265	3,588
Washington	3,009,337	7,964,167	4,598,332	4,862,702	755,898	858,531
Oregon	2,029,913	3,315,093	1,379,454	2,240,636	500,322	185,947
California	2,482,762	3,128,386	2,516,570	1,054,107	1,143,947	245,075
United States	151,322,840	115,309,165	82,535,407	65,791,848	36,195,085	17,518,640

fruit in carlots. The larger the quantity which he can supply, the greater consideration he will receive from marketing agencies and the more readily he can make a permanent place for himself in the market.

The local market will not absorb so large a quantity of fruit at a given time as the general market. It will often respond well, however, to a continuous supply in smaller

(*N. Y. C. Railroad Co.*)

Fig. 61. A typical view along the "Shore" rcad in western New York, showing a Baldwin orchard past middle life, but still producing heavily.

quantities throughout the consuming season. Whether this requires as large a producing area as the general market depends upon the extent of the local market to be served. This calls for a careful survey by the prospective grower before he determines the size of his orchard.

(*b*) *Consider Supplemental Farm Enterprises.* Considerable expense must be incurred and carried along from year to year until the fruit enterprise begins to bring in income. Commercial production of apples in the East cannot be expected before the trees are 9 to 10 years of age, for most varieties. In Western sections 6 to 7 years will be required as a rule. Prospective growers often underestimate this factor seriously in making their plans. The grower should consider the advisability of diversifying his enterprise by growing other crops the labor requirements of which do not conflict seriously with those of his orchard. Such crops may often be grown on areas on the farm not well adapted to fruit. An animal enterprise of some kind may also fit in well and provide another source of income.

In the older fruit sections, it has been the custom to operate the orchard as part of a general farm business, combining with it some annual cash crops and perhaps a livestock enterprise. In the newer sections, it is the prevailing custom to grow fruit in larger units and often to the exclusion of supplemental enterprises. Diversity of enterprises may be obtained by diversifying the kinds of fruit grown. The same equipment and general facilities are required for all, so that little additional outlay is involved. Annual crops may be grown between the trees, or additional land may be rented for this purpose, to give the grower an income until the fruit enterprise is ready.

The present tendency in all commercial sections is away from the 10- to 20-acre orchard on the general farm. It is increasingly evident that a fruit grower must be a specialist, centering his abilities chiefly on the production and marketing of his fruit. Consult Table 33, page 173.

3. Selecting the Land to Be Planted. In selecting the land for planting, good judgment and intelligent consideration may largely assure future success; the lack of them may bring mediocre results or absolute failure.

Procedure:

(*a*) Consider the elevation and slope.
(*b*) Consider the type and drainage of the soil.

(*a*) *Consider the Elevation and Slope.* Rolling land, or up-land acres, or sloping lands not too steep for efficient orchard practice are usually much better than level areas on river bottoms or valley floors. There should be land levels near by lower than that on which the fruit establishment is located, in order to insure continuous air movement or drain-

(*Michigan Exp. Station*)

Fig. 62. A Michigan peach orchard in which fruit buds on trees in the vicinity of *X* are frequently killed when those on trees about *O* at a greater elevation escape.

age, through and away from the planting. Frost pockets and attendant injury occur where the air is still, and fungus diseases flourish where the foliage dries off slowly (see Fig. 62). On the level areas of the eastern shore in Maryland and in Delaware a considerable fruit industry has developed, but here all the land is on the same general level and across it the sea and land breezes are frequently in motion.

Much advice that cannot be justified has been given in the past concerning slope or exposure. In nearly all fruit regions, successful orchards may be found sloping toward any point of the compass. If the section is subject to sudden and violent winds, a slope that will afford some protection is desirable. The influence of water on the climate disappears rapidly if the land slopes away from the water. Shallow water has little effect in any event. If winter injury is a factor, the slope that in the local experience seems to give the greatest measure of protection should be selected.

South slopes tend to accelerate development of buds in the spring; north slopes tend to retard it; east and west exposures fall in between.

(*b*) *Consider the Type and Drainage of the Soil.* The soil must be well drained and provide extensive root range. Fruit trees will thrive on a variety of soil types, but they will not tolerate wetness, and if they are to be thrifty and long of life, their roots must be able to penetrate the soil thoroughly. Heavy clay subsoil or continuous rock ledges or formations, near the surface and cutting off access to the soil areas below, are serious handicaps.

An occasional wet spot in an otherwise desirable field may be tile drained. Entire orchards have been thus treated with good results, but it would have been better business had they been planted on land that did not need artificial drainage.

A good upland corn soil has many of the characteristics of a good fruit soil, except that trees must root more deeply than corn. Peaches do best on the lighter types such as sandy loams, shales, etc. Apples and pears succeed on the loams containing appreciable quantities of clay and on all the ranges between them and peach soils.

As an indication of the influence of soils on the grade of fruit produced, Table 32 gives the grading records for a 5-year period from two Michigan apple orchards of the same varieties and about the same age under the same management and with the same treatment, but located on different soil types:

TABLE 32

Grades of Fruit in Percentage—5-Year Average of Two Michigan Apple Orchards, Similar in All Respects Except Locations on Different Soil Types *

Orchard	*A*	*B*	*C*	Canner	Under	Bulk
93	45	22	20	8	4	
94	24	12	58	4	2	

* V. R. Gardner, *Proceedings N. Y. State Horticultural Society*, 1928.

The New York State College of Agriculture has published a study of factors affecting the income of apple growers. Table 33 indicates the immense importance of the soil-drainage factor in relation to labor income. The figures relate to an extensive area in Niagara County. Evidence at hand indicates that the comparisons are valid elsewhere. On well-drained soils the third of the farms having the largest apple enterprise averaged about 1000 apple trees of bearing age, which was from 3 to 4 times as many trees per farm as the average of the lower third. The labor income, that is what the farmer had for his year's work, averaged $1308. These farms paid 3 times as well as the smaller third with an average labor income of $424. However, the smaller farms on well-drained soils paid, on the average, better than farms with large apple enterprises on soils not so well drained.

Sweet cherries seem to thrive best on deep, rich loams of the lighter types, sour cherries and plums on the somewhat heavier loams.

The nice adjustments of particular varieties to particular soil types have not been thoroughly worked out. A red variety will not color as well on the average, nor will fruit mature as early in the season on a clay loam as on a lighter soil type. The land should possess at least a fair measure of fertility as judged by ordinary crop requirements and, unless

TABLE 33

EFFECT OF SOIL DRAINAGE AND SIZE OF ORCHARD ON LABOR INCOME
Newfane-Olcott, Niagara County

Year	Farms Divided into 3 Groups According to the Size of Apple Orchard of Bearing Age — Median Averages		
	Low Third	Middle Third	High Third
Labor income			
Well-drained soils			
1933	$ 516	$1684	$ 912
1934	604	640	1438
1935	−214	84	−33
1936	937	1766	4011
1937	485	−51	20
1938	216	1083	1502
Average	$ 424	$ 868	$1308
Soils not so well drained			
1933	$−69	$−184	$−14
1934	44	−14	262
1935	−78	−100	−227
1936	217	409	790
1937	−56	−42	−268
1938	−5	−98	141
Average	$ 9	$ −5	$ 114

irrigation is to be practiced, should hold moisture in top soil and subsoil reasonably well.

4. Determining Time of Planting. Early spring is on the whole the best time to plant. It should be done as soon as the soil is in proper condition. There are usually marked differences in growth between trees planted even two weeks apart in favor of the earlier planted trees. It is important that the tree have the opportunity to esablish itself while moisture is abundant and before the hot dry weather of summer. Trees ought to make a considerable amount of growth the first season. The grower cannot afford not to have them do so. But they will not do this unless planted early and unless completely dormant at planting (see Fig. 63).

In milder sections, fall planting is successful if the trees are mature at digging time, the land is well drained, and the trees are set with especial care to insure surface drainage away from them. It is usually safer to plant apples and pears in the fall than the stone fruits. In the fall planting of peach trees, it is common practice to hill up the soil about the trees to protect them, removing it in the spring.

In those sections where either fall or spring planting is satisfactory, the grower will be governed principally by his labor schedule in determining the time of year to do the work.

5. Determining Varieties to Plant. The choice of varieties often constitutes the first serious mistake of the grower.

Procedure:

(*a*) Consider market to be served.
(*b*) Consider market tendencies.
(*c*) Consider variety characters and adaptations to various regions.
(*d*) Consider picking dates of varieties.
(*e*) Consider importance of cross-pollination.

(*a*) *Consider Market to Be Served.* This factor has already been considered in connection with determining the size of the enterprise. The general or wholesale market knows what it wants. It is better for the grower to bend his views to meet the evident desires of that market than to attempt to educate the trade to accept his personal opinions, though all reason and logic may appear to be on his side.

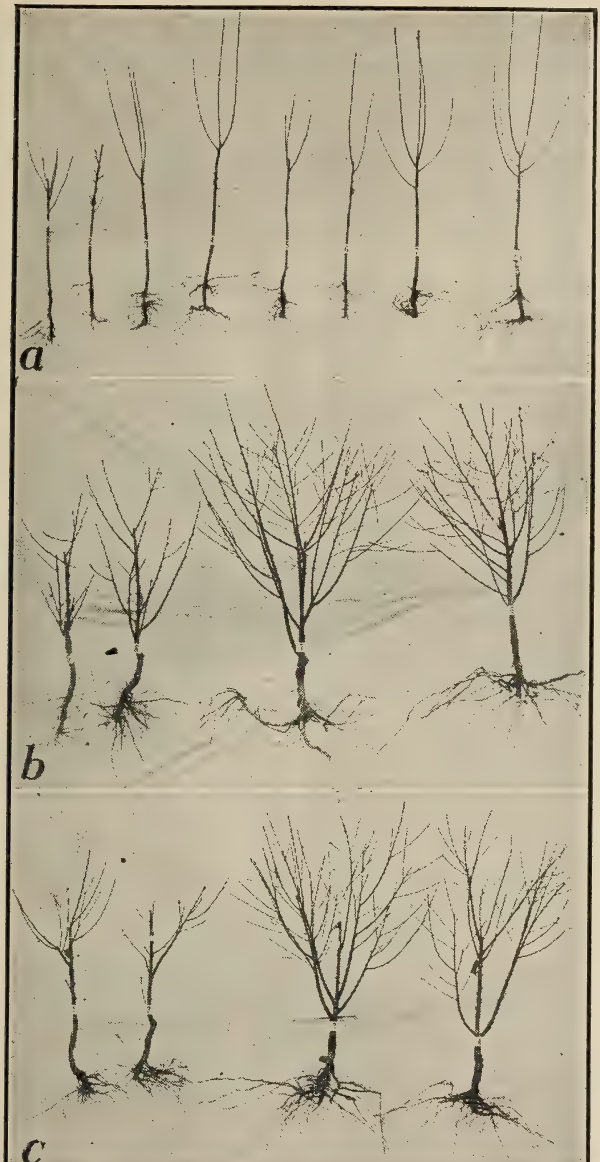


FIG. 63. (*a*) Yearling apple trees after one year's growth in the orchard. From left to right: trees 1 and 2 planted April 24, roots medium pruned. Trees 3 and 4 planted April 1, roots medium pruned. Trees 5 and 6 planted April 1, roots heavily pruned. Trees 7 and 8 planted April 1, roots unpruned. (*b*) Peach trees after one year in the orchard. All trees were planted on April 1. The roots of the first two were heavily pruned; the roots of the next two were unpruned. (*c*) Peach trees after one year in the orchard. The first two were planted April 24 after growth had started; the next two were planted April 1 while still dormant; root pruning the same. (Maryland Experiments.)

The local market is more responsive. It will accept varieties of high quality, even though they may not be well known, especially if the grower enjoys a reputation in the community as a skilled and reliable orchardist. This is true also of the roadside and motor truck demand now existing about the large centers of population.

(*b*) *Consider Market Tendencies.* In planting an orchard the grower is embarking upon a long-time enterprise. It is important for him to consider not only what the consuming public wants now, but what it is likely to want when his trees are in bearing. He should take account of any pronounced trends or tendencies that will aid in forecasting market demands. See Tables 21, 22 and 23, pages 100, 101, and 103.

The tendency is undoubtedly toward higher inherent quality. The tremendous and growing popularity of Delicious and McIntosh apples, for instance, is indicative of this fact. Growers cannot supply higher quality, however, than the public is ready to pay for. Some varieties of high quality would be grown to a greater extent commercially if they were not so expensive to grow by reason of light or tardy bearing, uneven ripening, high proportion of low-grade fruit; susceptibility to cold, insect injury, or disease; shortness of life, tendency toward bruising, or kindred ailments. The grower must consider all these items in making up his list, but must give quality a higher rating than in years past. Red varieties of apples, as a rule, sell better than green or yellow kinds.

(*c*) *Consider Variety Characters and Adaptations to Various Regions.* The best guide is the experience of the section in which the fruit is to be grown. Latitude is an indication, but variations in elevation may nullify the value of this as a guide.

The length of season required to bring a variety to maturity seems to be a most important factor in the distribution of apple varieties.

Studies made by the United States Department of Agriculture indicate that the different varieties of apples require rather definite periods of time following full bloom to reach the correct stage for picking and that these periods do not vary greatly from year to year. For some of the important commercial varieties these periods, dating from the time the first petals begin to fall, are:

	Days		*Days*
Yellow Transparent	60–65	Baldwin	145
McIntosh	125–130	Delicious	145–150
Cortland	130	Ben Davis	150–155
Rhode Island Greening	140–145	Rome Beauty	160–165
Jonathan	140–145	Stayman	165
Grimes	140–145	Winesap	165–170

This does not mean that the grower of McIntosh, for instance, should pick his apples in exactly 125 days from date of full bloom. It does mean that he can compute the picking period closely in advance, make his plans accordingly, and then vary the dates in accordance with his own conditions and the other factors affecting the date of picking.

The grower should study the characteristics of the different varieties that he has under consideration for planting. Some varieties of superior quality, bring high prices, come into bearing later than others under the same cultural practices. Some tend to bear a crop in alternate years (biennial), or are unusually susceptible to such diseases as scab, cedar rust, fire blight, etc. Varieties may be hardy and resistant to cold, or susceptible to it; they may normally mature a large proportion of their crop that will grade well, or that will be inferior in size and color. Some are so tender as to require the most careful handling to avoid bruising.

New varieties should prove themselves strongly before the grower permits them to displace the profitable veterans of years in his planting list.

In case of apples, the summer and early varieties have a larger place in some sections than others. In New York and Ohio, winter varieties hold chief place. In southern New Jersey, Delaware, and Maryland, they share honors with Yellow Transparent, Starr, Oldenburg, Williams, and other early sorts. In general, summer or early varieties are meeting heavy competition from other fruits. Lists of varieties for various regions are given under General Information.

(*d*) *Consider Picking Dates of Varieties.* The greatest rush of work in the orchard usually comes at harvest time. Choose enough varieties to give a good distribution of labor through the harvest season, but keep in mind that three or four varieties for 50 acres, making possible quantity shipments of each variety, are much better than ten varieties. With a larger acreage, or for a local and special trade, the number might be increased. A common mistake of the beginner is to select too many varieties.

(*e*) *Consider Importance of Cross-Pollination.* Some varieties are self-sterile. Some varieties are intersterile, that is, the pollen of one variety will not fertilize the blossoms of the other variety. Other factors, including the weather at blossoming time, enter in. The matter is presented fully in Chapter VIII, "Pollination." It is only necessary to say here that it is not advisable to plant a single variety in a large block. It is not necessary or desirable to mix varieties in the row. Plant several rows of a single variety, probably not less than two or more than four, and alternate with at least one row of another variety of the same, or an overlapping, blooming period.

6. Determining Planting Distances and Planting Plan. The grower should plant his trees at such distances that they may have the opportunity for development in accordance with the best known standards and that he may carry on the necessary orchard operations to advantage. He should follow a planting plan or arrangement that will conserve the use of his land, or that will give greatest economy and efficiency in care and management.

Procedure:

(*a*) Consider size of mature trees.
(*b*) Consider advisability of fillers.
(*c*) Consider merits of various planting plans.

(*a*) *Consider Size of Mature Trees.* Growers have difficulty in visualizing the amount of space needed by the tree at maturity. At least 75 percent of the present commercial orchards are examples of too close planting. What constitutes adequate space may be defined only when the region, the soil, and the variety are known. Fruit trees grow much larger in some sections than in others. A Baldwin tree on strong soil in New York will use 50 feet at maturity. In the scantier soil of New England, 40 feet or even less is enough space for it. Wealthy, Yellow Transparent, Ben Davis, Wagener, or Jonathan do not require as much space in any section as do York Imperial, Stayman Winesap, McIntosh, or Rhode Island Greening. The Morello cherry needs less space than Montmorency. Table 34 is an approximation only, with emphasis on the greater distances.

TABLE 34

PLANTING DISTANCES FOR PERMANENT TREES

	Feet		Feet
Apple	35 to 50	Sour cherry	20 to 25
Pear	22 to 30	Sweet cherry	25 to 35
Quince	18 to 20	Plum and prune	18 to 25
Peach and apricot	20 to 25		

(*b*) *Consider the Advisability of Fillers.* A filler is a tree inserted in the orchard to supplement the income from the orchard until the permanent trees need all the space. Some growers prefer to secure this income by growing annual crops between the permanent trees, instead of using fillers. A filler may be of the same kind and variety as the permanent or it may not.

In sections where the peach may be grown commercially, it has frequently been used for interplanting in the apple orchard. However, sentiment against the plan, based on commercial experience, is growing strongly. With increasing use of sod culture for apples and better methods of fertilization, pruning, and of borer control, all contributing to longer life, the peach may best be planted alone.

Sour cherries may be used as fillers. Pears, excepting of the type of Kieffer, LeConte, or Garber, should not be interplanted with apples because of the danger of fire blight, difficult enough to control in some varieties of apples at best.

If apple trees are planted at the maximum distances, there are some apparent advantages in using the same variety as filler. The first choice for a filler is a desirable variety of apple that is a small grower and comes into bearing quickly.

Fillers increase the difficulty of cultivation, spraying, and other orchard operations. The chief objection that may be urged against them, however, is that they seldom are removed before they have interfered with and retarded the development of the permanent trees. This is a criticism of the grower rather than the system, but the temptation to leave the filler "just another year" is very real and strong, a fact that may well be faced at the outset.

In general, if there is a profitable market for annual crops, or a place for them in the system of farm management, and if land is available at a reasonable figure, the orchardist may well spread his trees over more acres, adopting an extensive rather than intensive method of planting.

Bush and small fruits, as grapes, currants, gooseberries, and strawberries, are interplanted between trees in certain sections, permitting high returns per acre and intensive use of the land. The plan has its disadvantages, among which are difficulty in spraying and other operations, and frequent overcrowding and interference before the plantings are removed.

(c) *Consider Merits of Various Planting Plans.* The grower should decide upon his planting plan before ordering his trees. Given the distance between the trees, the plan or arrangement will determine the number required for a given area.

The *square* system is widely used. The trees are equal distances apart and at right angles to each other, with a tree on the corner of each square. Simplicity in laying out and ease of cultivation and spraying characterize this arrangement. If the trees are planted too closely, it is easy also to thin them out by removing alternate trees.

The square system is the most desirable if fillers are to be used. With a permanent tree on each corner of the square, a filler or semi-permanent may be placed in the center of the square. Thus, if the permanent trees are 40 feet apart, the semi-permanents will be 28¼ feet from each permanent. This is known as the *quincunx* method. Additional fillers may be placed in both directions if desired, making all trees 20 feet apart.

The square system may be modified by making the rows farther apart from east to west than from north to south, permitting the maximum access of sunlight to the trees and constituting what is sometimes called the *rectangular* system, as distinguished from the square method.

The hexagonal or *triangular* system brings the permanent trees in the adjacent row not opposite the trees in the first row adjoining, but opposite the center of the spaces between the trees. The trees are the same distance apart as in the square system, but space is saved and more trees may be planted per acre. Thus, the square system, 40 by 40, gives 27 trees per acre, whereas the hexagonal system, 40 by 40, gives 32 trees per acre. This system is a little more difficult to lay out than the square system and is not so well adapted to the use of fillers.

Special systems developed to meet local conditions may be required where the land is steep, the topography irregular, or the soil inclined to wash badly. Trees may be planted according to the contour of the land, such cultivation as is done being across the slope rather than up and down it. Such an arrangement, however, does not contribute to convenience or efficiency from the commercial standpoint.

Table 35 gives the number of trees per acre at given distances, depending upon the plan of planting:

TABLE 35

Number of Trees Per Acre at Given Distances According to Plan Used

Distance Apart in Feet	Number of Trees per Acre *		Distance Apart in Feet	Number of Trees per Acre *	
	Square	Hexagonal		Square	Hexagonal
18	134	154	35	35	41
20	108	124	40	27	32
22	90	104	45	22	25
25	70	80	50	17	20
30	48	55			

* Obtained by dividing 43,560, the number of square feet in an acre, by the land area devoted to each tree (in the square system the area of the square, in the hexagonal system the area of the parallelogram). Slight variations from this table will be encountered in actual practice, depending on space left at ends, sides, etc. The quincunx system will usually accommodate about 75 percent more trees than the square system, or if the number of rows and trees in the row are the same for fillers as for permanents, the quincunx system will double the number of trees.

Plenty of space for turning should be reserved at the ends of all rows. The amount will be influenced by the presence of fences, hedgerows, etc. Usually more than one-half the distance between permanent trees, or about 30 to 35 feet, should be left at the ends of the rows to facilitate orchard operations.

7. Purchasing Trees. The grower is now ready to place his order for trees. This should be done well in advance while the best stock is available. Trees for spring planting should be ordered during the preceding fall or early winter.

Procedure:

(*a*) Consider age and grade of trees.
(*b*) Consider sources from which trees may be obtained.

(*a*) *Consider Age and Grade of Trees.* The age of trees is measured by the age of the top without regard to the age of the root. Since our standard varieties do not come true from

(*Washington Nursery Co.*)

Fig. 64. Budded Bartlett pear trees beginning their second year of growth in a Washington nursery.

the seed, it is necessary to resort to budding or grafting to obtain them. Seedlings are grown from the seed or pit for one year, either in France or the United States. They may be dug in the fall, root grafted to the desired variety in the winter, and set in the nursery row in the spring; or, as is the more common practice, the seedlings may be transplanted to the nursery row in the spring and budded in late July or August to the desired variety. In the latter case, the bud does not begin to grow until the following spring. Peaches constitute an exception in that they are grown from pits in this country and are budded the first season. In Southern sections, they are sometimes budded in June, the buds grow at once, and the resulting trees are known as June buds. The age of trees in the nursery trade relates to the age of the graft or bud from the time it begins to grow on the stock. The process of budding and grafting is more fully described in the chapter entitled "Propagating Fruit Plants."

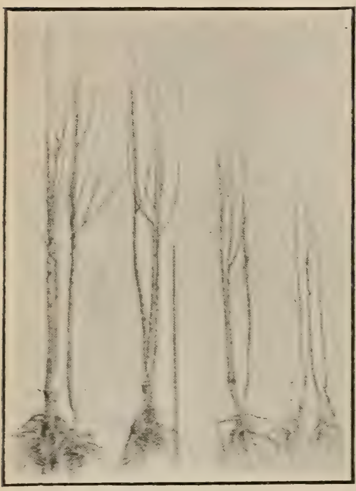


Fig. 65. Peach trees showing the various sizes available for planting. Those just at the left of the measuring stick are popular.

Peach trees are sold at one year of age (Fig. 65), except June buds, which are younger. Sweet cherry trees, somewhat difficult to transplant, may best be purchased at one year of age, though many are sold at two years. Apples, pears, sour cherries and plums are commonly sold when two years old (Fig. 66). Older trees should not be purchased for commercial purposes. The shock of transplanting them is greater than for younger trees, and their prolonged stay in the nursery row reduces their vigor.

There is an increasing demand by growers for strong one-year apple trees, and to a less extent for one-year trees of the other fruits commonly sold at two years of age. Such trees cost a little less than two-year trees, transportation charges are lower, they stand transplanting better, and start into growth sooner. It costs less to set them because they can be handled more easily and do not require so large a hole for the roots. The chief consideration, however, in the apple is that, since the one-year tree comes as a straight whip, the grower may form the head at any height and in any way that he chooses. The two-year trees, on the other hand, come with side branches already formed. The grower must either select the foundation for the head from them, or if the branches are placed too closely together, he must remove part of them and

(*U. S. D. A.*)

Fig. 66. (*a*) Well-grown one-year-old Stayman Winesap apple trees. (*b*) Good two-year-old trees of the same variety.

develop the head over again. A nurseryman may develop a better head on a tree than an inexperienced grower, but the skillful grower who will give the matter attention may well purchase the one-year tree. Trees planted side by side at one and two years of age cannot be distinguished in the orchard four or five years later, so far as size is concerned.

Trees are sold as large, medium, and small, or XXX, XX, and X, respectively, with the height and caliper given. Varieties differ greatly as to habit of growth and size at a given age. The XXX is in greatest demand. Nothing less than the medium size should be selected, as the small trees are often stunted and lacking in vigor. Abnormally large or overgrown trees have very little to commend them.

Dwarf trees have little place in the commercial orchard. They have not justified the claims that have been made for them. Although some of them come into bearing noticeably earlier than standard trees, they are easily uprooted and must be planted so closely, in order to obtain a satisfactory yield per acre, as to interfere seriously with cultural operations. On small areas and for the amateur they are worth consideration.

Pedigree trees do not have the virtues implied by the name. The term implies that nursery trees have been propagated from selected strains of the variety that possess higher qualities of color, productivity, etc., than the average of the variety and that these characters will be transmitted. Such differences when traced or tested under controlled experimental conditions seem due to soil or climatic factors, or to variations in management, and not to characters that can be transmitted by budding or grafting, except in case of bud sports.

It is well to propagate nursery stock by using buds or scions from bearing trees, not to perpetuate special characters of the individual tree but to insure trueness to name.

There are severe limitations on the extent to which nurserymen can use propagation wood from bearing trees. The annual growths are often short, the buds may be weak, and the time and effort expended in securing satisfactory propagation wood may greatly increase the cost of propagation.

Improvement in fruit varieties must come primarily not through change in existing varieties, but through the discovery of variants, or sports, and the scientific breeding by crossing of varieties we already possess. Among the sports or mutations in apples may be mentioned Gallia Beauty and Red Rome (both strains of Rome Beauty), Starking (Red Delicious), Red Gravenstein, Red Duchess, Black Stayman Winesap, and Red Spy. The origin of some of these is so obscure that they may be seedlings rather than sports. Among new apple varieties obtained as the result of scientific breeding programs are the Cortland, Early McIntosh, and others originated at the New York Agricultural Experiment Station at Geneva and many by Macoun in Canada and by Beach in Iowa. The New Jersey Station has bred a considerable number of promising peach varieties, and the Geneva Station has developed the Sheridan grape and many varieties of small fruits. The United States Department of Agriculture has done work along similar lines.

Certified Trees. Some nurseries are now advertising "certified" trees for sale at prices slightly in excess of the regular charges for trees of the same age and grade. The term as used here means that these trees have been examined in the nursery row by official agents and have been certified as being true to name.

Some nurserymen and experienced tree growers have long been able to identify many varieties from their appearance as they grow in the nursery. The shape and manner of growth of the tree, color of bark, and appearance of the leaves are all factors.

The Massachusetts Agricultural Experiment Station has made an extended study of the leaves of apple trees. It has established that leaves on wood of the current season's growth, especially those occurring on the middle portions of such wood, are very important and dependable factors in identification. Injured or malformed leaves or those growing on interior shoots or on undernourished trees are not typical.

The appearance of the petiole or leaf stalk and the angle which it makes with the parent branch are helpful. The size and shape of the leaf, the shape of the leaf tip, etc., bending or folding of the leaf blade, and of the margin, and especially the serrations along the leaf edges are determining factors.

The thickness of the leaf, its network of veins, its pubescence or hairiness on the undersurface, and its color are supplemental factors.

The Horticultural Experimental Station of Vineland, Ontario, Canada, has made similar determinations for pears, plums, peaches, and cherries, and the Minnesota Experimental Station for plums and raspberries.

(*b*) *Consider Sources from Which Trees May Be Obtained.* Trees grown north or south, east or west, of the location where they are to be used are no better and no worse by reason of that fact. There is no merit, however, in assuming extra transportation charges or inviting loss or damage due to extended periods or delays in transit.

Purchase from a reputable concern. Trees at bargain prices are usually expensive investments. Specify a good, well-grown tree and expect to pay what it is worth. Purchase subject to inspection before acceptance, and specify that no substitutions in the order are to be made without written consent.

It is good practice to visit the nursery and make a personal selection where possible. If the nursery is near by, the trees may be delivered or called for by truck when the field is ready for planting, avoiding delays in transit and storage of the trees at the farm.

8. Caring for Trees on Arrival. Inspect all stock carefully on arrival. Check varieties, number, and grade. Reject all trees showing evidence of crown gall, unless it can be easily pruned off, hairy root, severe aphis injury on the roots, or of winter killing as indicated by brittleness of the wood and discoloration of the tissues when branch or trunk is broken.

If the trees are in good condition and are to be planted within two or three days, they may be put on the cellar bottom in the basement or storage shed, out of the sun, soaked thoroughly with water, and covered with blankets or straw.

If there must be delay in planting, the trees should be heeled in at once, preferably on the north side of a building, or on a slope away from the sun to retard development of the buds (Fig. 67). Plow out a deep furrow or trench, separate the trees, which come in bundles of ten, and place them in a sloping position against the furrow side of the trench, plow a furrow back over the roots, finishing with a shovel to insure exclusion of air from the base of each tree. Another row of trees may now be placed in the second furrow and so on.

(*Missouri Exp. Station*)

FIG. 67. One-year apple trees heeled in. If they are to be left for an extended period, the bundles should be opened and the trees distributed more evenly along the trench.

The roots may be pruned before heeling the trees, avoiding the necessity of taking time to do this at planting. Torn and broken ends and long straggling roots may be clipped off. Root fibers which are so abundant as to prevent thorough packing of the soil about the roots may be thinned out. There is evidence, however, that very little root pruning should be done. That which seems necessary may be done very rapidly with a pair of hand pruners.

9. Preparing Field for Planting.

Procedure:

(*a*) Preparing the soil.
(*b*) Determining location of trees.

(*a*) *Preparing the Soil.* Plow orchard land as early in the spring as soil conditions permit. This will insure both settling of the ground before planting and conservation of the moisture, which the trees will need. Plowing in the fall and working the land in early spring are desirable in many sections. It is better that the land should have been devoted to a tilled crop the year previous rather than that trees be planted on a freshly turned sod, though the latter is by no means to be disallowed under all conditions. If planting on sod, fall plowing is particularly desirable, so that the soil may settle and disintegration of the sod may begin before the trees are set.

Peaches should always be set on tilled land. In some sections extensive apple orchards have been developed under conditions that do not permit tillage, and some growers use other systems of soil management through preference. These are described in the chapter "Managing Orchard Soils." It is best to set in tilled land whenever possible, regardless of the type of soil management followed later.

(*b*) *Determining Location of Trees.* A simple method of staking a field that is fairly level is indicated in Fig. 68, showing trees to be set 40 by 40 feet on the square, 30 feet to be allowed on the ends of the rows beyond the last trees for turning, given one straight side of the field, as a road or line fence (which side does not matter).

Turn a right angle at one corner of straight boundary or base line, as indicated by *m*, in the triangle, Fig. 68, by measuring 60 feet along the base line and parallel with it, and setting stake 1; measure 80 feet approximately at right angles to *m*-1, and set stake at *n*. Then change the position of *n* until the distance *n*-1 is exactly 100 feet without altering other dimensions (smaller triangles as 30–40–50 may be used, but the chance for error on the shorter distances is greater).

Referring now to the large map of the field and turning the right angle at point *A*, project lines on two field lines, but not where trees are to stand. From point *A*, set the first stake, 30 feet along the line *A–B*, marking the location of the outer row. Set the remaining stakes 40 feet apart. The last stake should be 30 feet from *B*. Set the first

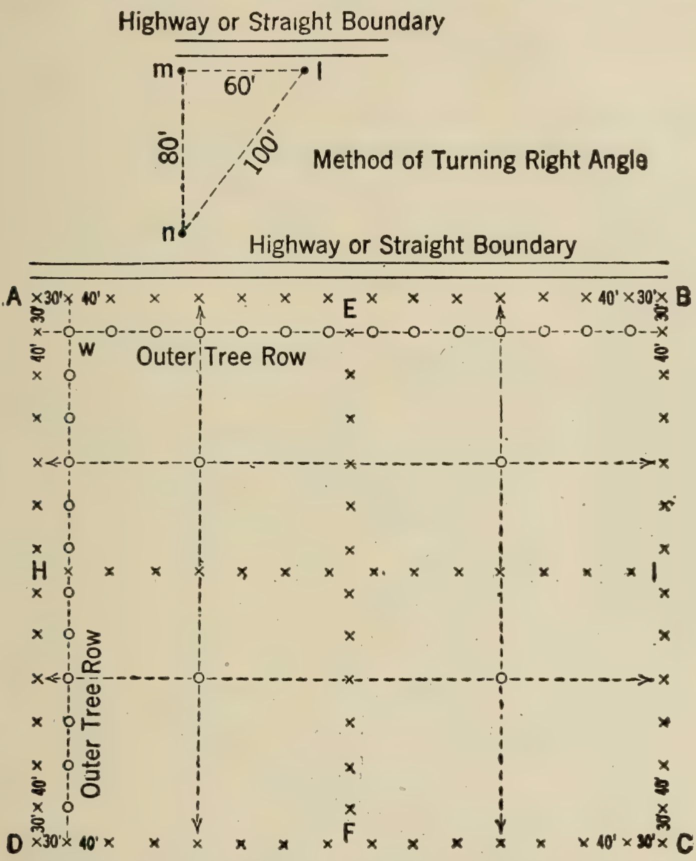


Fig. 68. Method of staking the orchard. Where two lines of sight cross over the stakes is the place for a tree. o indicates some of these points.

stake along *A–D*, 30 feet from *A*, and all other stakes 40 feet apart, excepting the last stake which should be 30 feet from *D*.

At *B*, erect another right angle, and set line *B–C* along the boundary. Close the end *C–D*, testing to see that *A–B* and *C–D* check as to length and altering points *C* and *D*, until the measurements are the same. This may make necessary slight adjustments of the stakes in lines *A–D* and *B–C*. Disregard irregular planting areas that fall outside the plan, as these may be filled in easily after the main area is set.

The boundaries of the orchard are now determined with no stake that is in the way of a tree. It is now necessary to put in additional rows of stakes through the interior of the field so that, standing within the field, two stakes may be seen in line in each direction.

Set *E–F* and *H–I* and as many more rows in each direction as may be necessary, turning right angles as before. Do not set in tree rows, but between them as indicated.

Ordinary building lath are very satisfactory for stakes. For rolling land, they may be spliced together to give greater height for the hollows. A white cloth may be wrapped around them or they may be dipped in whitewash when used for long distances or against a background that makes it difficult to see them.

Point *W* indicates the position of a corner tree. Any point in the field where two lines of sight cross is the place for a tree. Small stakes may be set where each tree is to go, or the place may be determined by sighting-in the reversed shovel as a stake, digging the hole at once. The latter method is satisfactory only with careful men. When a stake is placed a few inches out of line and is used in turn for sighting, the error accumulates as the length of the row increases and may be considerable at the end. In order to reduce the possible error, it is best to plant the trees or set the interior stakes in one direction only, rather than to work across the field and back, planting or staking in both directions.

Two men may set the outer stakes. A third man, who can stay back and do the sighting while the others are measuring the distances, will save much walking back and forth. Three are needed for such lines as *E–F* and *H–I*, two men sighting in the stakes, one in each direction, while a third sets the stakes as they indicate. If stakes are to be set at the location of each tree, three men will do the work much faster and more accurately than a smaller number. Almost any number of gangs may work without interference in a field so staked, and the original guide stakes are always in place until the job is done.

There are many variations of the foregoing plan. The outer stakes may be set where the trees are to go and then removed only after the other trees have been planted. In Southern sections, a colored man with one mule, given a few stakes to go by, will plow out furrows and cross furrows very accurately. A team may be used, sighting between the horses. In large plantings and on rough land, the plan outlined may be too laborious and expensive, although the work, once the boundaries are established, goes quickly. Wire marked at the proper distances, or measuring sticks as long as the distance between trees, may be used. Cord is not satisfactory for measurements because of its tendency to stretch with use or to shrink when wet. Steel or linen tapes are preferable.

Fig. 69. Although this orchard was planted on level land, making it easy to lay out the rows accurately, this view along a row indicates little effort to do so.

Whatever the plan used, time taken in the interest of accuracy when planting is time well spent. Trees much out of line, as in Fig. 69, are not merely an eyesore, they interfere seriously with orchard operations, especially in closely planted orchards. A discrepancy of a few inches will gradually disappear and be "taken up" by the tree in the course of development.

The planting plan for the hexagonal system does not vary except that distances between rows, not between trees, are different and the staking must correspond. A wire triangle, each side representing the distance between trees, with rings at the corners for staking will help.

In working on uneven ground, keep the measuring tape or device level rather than following the contour of the ground.

It will save time to map the outer boundaries and inner guide stakes on paper before undertaking to lay out the field. Use the actual distances of planting adapted to a convenient scale, and proceed in accordance with the conditions that must be met. Every step will then be thoroughly understood before the work begins.

10. Planting the Trees.

Procedure and Factors:

(*a*) Preparing the hole.
(*b*) Handling the trees.
(*c*) Setting the trees.
(*d*) Subsequent treatment.

(*a*) *Preparing the Hole.* Dig a hole that will accommodate the root system. Even though the rows have been plowed out, the hole must be finished with a shovel. Make it correspond to the root system of the tree and deep enough so that the crook at the base of the tree will be just below the ground level. If the subsoil is poor, dig the hole deep enough so that some moist and fertile top soil may be put in the bottom. Keep the top soil separate from the subsoil so that it may be used about the roots.

Dynamite may have value in orchard planting under some conditions. It may break up a shallow layer of hardpan, affording a better medium for the roots. If the hardpan is deep, dynamite will merely make a pocket where water will settle. It should not be used when the soil is wet and, in general, the hole should be blasted well in advance of planting. It will take nearly as much time after blasting to prepare the hole for planting as it would have taken to dig the hole in the first place. It is thus not a cheap method of putting trees in the ground. In general, if the soil needs dynamiting to make it suitable for tree planting, it would be better to plant on a field that did not need such treatment. If dynamite is used, follow the directions of the manufacturers.

Recent experiments have shown that, by mixing a 12-quart pail of wet pulverized peat moss with the soil which is placed around the roots at planting time, a much more vigorous tree results at the end of the second year's growth. This material holds moisture in reserve if dry weather follows, and it improves the condition of the soil if the weather is wet. It may be that this will become standard planting practice, especially on soils low in organic matter.

Do not put manure or commercial fertilizers in the hole. Manure may cut off the roots from subsoil moisture and is used to much better advantage as a mulch on the surface after the tree is set. Commercial fertilizers may be used most efficiently as indicated in the chapter "Managing Orchard Soils."

(*b*) *Handling the Trees.* Keep the roots protected from the sun and wind by covering them with a wet blanket or by putting the trees in a tub of water on a wagon or stoneboat. If the trees are dropped much ahead of the planters, cover the roots with a little soil to protect them until the planting gang arrives. Growers who have purchased good trees are often very careless in protecting the roots during the planting operation.

(*c*) *Setting the Trees.* Set the tree so that the lower branches which are to be retained for the head, or the crook of the central leader, are toward the prevailing wind. The wind will gradually push these branches upward toward the center of the tree, so that they will not bend toward the ground. If planting on a slope, the lower branches to be retained should be on the downward side, to give them as great an elevation from the ground as possible. For one-year trees which are straight whips, these directions do not hold until the head is being formed.

Sight-in the tree, and throw in two or three shovelfuls of moist top soil. Lift and shake the tree gently to work the first shovelfuls about the roots. Let one man hold the tree in place, tramping the soil firmly about the roots as it is thrown in, not by pressing it with his toe, but by treading solidly around the tree with both feet in the hole. The most important single factor in planting a tree is to plant it firmly. Not only is the tree then well anchored from the physical standpoint but also air spaces are reduced and the soil particles and soil moisture are in intimate contact with the root system. If the soil is wet, less tramping is desirable since the ground will settle itself. Fill the hole above ground level to allow for settling, and leave the soil loose on top to prevent drying out.

Often better progress will be made if one gang digs the holes and another plants the trees. A trial will determine the most efficient size of the planting gangs.

(*d*) *Subsequent Treatment.* Do not prune the tops until after the orchard is planted. Some branches may be injured or broken in the planting operation. Leave them all until the job is done. Then one man can go through and prune them very rapidly and according to the same plan and standard. It may be done any time within two or three weeks after planting. Directions are given in the chapter on pruning. Opinion differs as to the advisability of pruning fall-planted trees before spring. There seems little reason why excess branches should not be removed at once.

To prevent excess evaporation and thus give the trees a good start, the young trees are sometimes coated with an emulsion of wax.

Map the orchard as to varieties and their location when the planting job is completed. File the map with a copy of the order and bill. This will be helpful and interesting later and may also be an aid if varieties prove untrue to name.

GENERAL INFORMATION

1. Apple Regions and Varieties

The commercial fruit areas of the United States and Canada are quite well defined. Since most sections are now well served by transportation facilities, the fruit sections are determined chiefly by climatic factors and to a less extent by soils. A section may also be adapted to the growing of fruit, but better adapted to some other crop. Extensions of the industry into such sections may be looked for as economic conditions warrant. In general, however, the commercial areas have been determined and it is in them or parts of them that most of the fruit for market will probably be produced in the future.

In naming these regions it must be kept in mind that they are not adapted in their entirety to fruit production. Local factors enter in, and much must be left to judgment and local experience.

The deciduous fruit regions have been determined largely on the basis of apple growing. Although other fruits will not thrive in all the apple sections, particularly in the ones with low winter temperatures, yet it is a fact that the growing of the other fruits takes place to a large extent in the apple regions. Certain peach sections constitute exceptions to this statement.

As has already been pointed out in the section on selection of varieties, varieties differ in their adaptation. In defining the fruit sections it becomes possible to indicate the varieties of commercial prominence or promise for them.

In general, the northeastern states are adapted to fruit growing, and it is in these states that the industry first took on the aspects of a commercial enterprise. Other sections have since come to the fore and are providing competition that is both keen and at the same time helpful in raising the standards of the industry.

The chief fruit regions are outlined here without regard to order of importance. Commercial rank is somewhat variable, and its emphasis is shifting. It may be determined for any period in a general way from the census figures of bearing and non-bearing trees and a study of carlot shipments.

1. The New England states, excepting the colder sections of Maine, New Hampshire, and Vermont.

2. New York, comprising the western New York, Hudson Valley, and Lake Champlain areas.

3. Michigan, in the southern half of the state, but also well distributed along the eastern shore of Lake Michigan.

4. Ohio, quite generally distributed with large production in the southeastern counties, along the Pennsylvania line, and about Lake Erie.

5. Pennsylvania, about large industrial centers, along Lake Erie, and in the south-central section forming a part of the Shenandoah-Cumberland region.

6. New Jersey-Delaware and eastern shore of Maryland. These areas are close to large consuming centers. They feature summer and fall apples but also grow winter apples.

7. Shenandoah-Cumberland region, including south-central Pennsylvania, western Maryland, eastern West Virginia, and Virginia.

A southern extension of the area reaches into the mountain sections of North Carolina, north Georgia, and northeastern Alabama. The Piedmont section, so called, is along the eastern slope of the Blue Ridge Mountains in Virginia and is mountainous in character.

8. Southern Illinois and Indiana.

9. Ozark region of southwestern Missouri, eastern Oklahoma, and northwestern Arkansas. There is also a small commercial section in northwestern Missouri.

10. Northwest, including areas in Oregon, Washington, Idaho, western Montana, and British Columbia. This territory produces more than 80 per cent of all box apples grown in the United States and Canada at the present time. Well-known sections are the Okanogan of British Columbia, the Wenatchee and Yakima Valleys of Washington, and the Hood River and Rogue River Valleys of Oregon. Cherries, prunes, and pears are grown extensively in some areas, in addition to apples.

11. California in the Watsonville district, chiefly in Santa Cruz and Monterey Counties and in the Sebastopol area in Sonoma County. There is also a commercial development at Yucaipa in San Bernardino County. Conditions and varieties in these districts vary greatly. The box is the market package.

12. Mountain States including limited areas in Colorado, Utah, and New Mexico. The box is used for packing.

13. Canada, in addition to the area in British Columbia included in the Pacific Northwest territory, has important sections in the Annapolis and other valleys of Nova Scotia and in the Province of Ontario along the Great Lakes. Other sections occur in the Provinces of New Brunswick and Quebec.

The **varieties of apples** listed are the major commercial varieties in the sections named, at the present time, or show promise of becoming so. In selecting a planting list, check the varieties against local experience and the recommendations of the local experiment station. Other varieties may be worthy of consideration, but may not as yet have definitely established their qualifications from the commercial standpoint.

The fact that certain varieties are dominant in commercial sections at the present time is not conclusive evidence that they will remain so. Inspection of varieties in non-bearing orchards and in those being planted will indicate the trend. In general, the movement is toward higher quality as exemplified by the McIntosh and Delicious types in their respective regions. Red sports or strains of some varieties as Red Rome and Gallia Beauty, Starking, Red Duchess (Oldenburg), and Red Gravenstein are available and may be preferable to the older forms of these varieties. Several introductions of summer apples by the

Geneva (New York) Experiment Station, as Milton, Early McIntosh, and Melba, are worthy of trial, especially for local trade.

A indicates summer and early fall apples, when grown in quantities.

B indicates the late fall and winter varieties. The same variety may be a fall apple in one section and a winter variety in another section.

Variety descriptions with special notes on local behavior are available from so many authoritative sources that such descriptions are not included here.

Check these lists with the state experiment station or college of agriculture.

NEW ENGLAND

A—Wealthy, Gravenstein, Oldenburg. *B*—McIntosh, Baldwin, Northern Spy, Rhode Island Greening, Delicious, Fameuse.

NEW YORK

A—Oldenburg, Wealthy. *B*—McIntosh, Baldwin, Rhode Island Greening, Northern Spy, Cortland.

The planting of Oldenburg, Wagener, Tompkins King, and Twenty Ounce is decreasing. Northern Spy, though slow to come into bearing, is a desirable variety in favored locations.

In the *Hudson River Valley* the list of varieties is much the same as for western New York. McIntosh and Cortland, however, have been planted on a larger scale, and Rome, Delicious, Yellow Newtown, and Red Gravenstein are grown commercially. Jonathan, while grown, is decreasing in popularity. To lengthen the McIntosh season in some sections, the Kendall and Macoun are becoming quite popular.

In the *Champlain Valley,* resistance to cold is a prime factor. McIntosh, Northern Spy, and Fameuse are in the lead. Wealthy, Alexander, and Wolf River are also grown.

MICHIGAN

Southwestern Michigan

A—Wealthy. *B*—Rhode Island Greening, Northern Spy, Baldwin, McIntosh, Fameuse, Delicious.

Oldenburg or Duchess has been extensively grown in Michigan, but is not now proving profitable. In *northeastern* Michigan Northern Spy, McIntosh, and Fameuse predominate.

OHIO

A—Yellow Transparent. *B*—Rome Beauty, Baldwin, Rhode Island Greening, McIntosh, Delicious, Stayman Winesap.

PENNSYLVANIA

In the northern half of the state, varieties are the same as those in the western part of New York. Southeastern Pennsylvania forms part of the Shenandoah-Cumberland belt and grows the varieties listed for that region.

NEW JERSEY, DELAWARE, AND EASTERN SHORE OF MARYLAND

A—Yellow Transparent, Starr, Oldenburg, Wealthy, Williams. *B*—Stayman Winesap, Winesap, Delicious, Rome Beauty, Jonathan, Grimes, York Imperial, Baldwin (northern New Jersey).

SHENANDOAH-CUMBERLAND REGION

A—Yellow Transparent, Summer Rambo, Williams, Oldenburg, Wealthy, Northwestern Greening. *B*—York Imperial, Stayman Winesap, Winesap, Rome or Gallia Beauty, Delicious or Starking, Jonathan, Arkansas (Mammoth Black Twig, or Paragon), Grimes, Ben Davis.

In some sections of the Piedmont region of Virginia the Yellow Newtown or Albemarle Pippin develops to a high state of perfection.

SOUTHERN ILLINOIS AND INDIANA

A—Yellow Transparent, Oldenburg, Maiden Blush, Benoni. *B*—Winesap, Stayman Winesap, Jonathan, Kinnard, Rome Beauty, Delicious, Ben Davis.

OZARK REGION

A—Yellow Transparent, Oldenburg, Ada Red. *B*—Ben Davis, Gano, Jonathan, Stayman Winesap, Delicious.

NORTHWEST

B—Winesap, Jonathan, Stayman Winesap, Rome Beauty, Delicious.

In the Hood River Valley, Yellow Newtown and Esopus Spitzenburg are grown extensively. In British Columbia, McIntosh and Northern Spy are grown to some extent.

CALIFORNIA

Watsonville District

B—Yellow Newtown, Yellow Bellflower.

Sebastopol District

A—Gravenstein.

Yucaipa District

B—Rome, Winesap, Delicious, King David.

MOUNTAIN STATES

B—Jonathan, Rome, Winesap, Delicious.

In the higher altitudes, Yellow Transparent, Wealthy, Northwestern Greening and McIntosh are grown in a limited way.

CANADA

Ontario

A—Yellow Transparent, Oldenburg, Wealthy, Alexander, Melba. *B*—Northern Spy, McIntosh, Fameuse, Baldwin, Rhode Island Greening, Delicious, Tolman.

Some of Macoun's introductions are being tried in a very limited way.

Nova Scotia

A—Gravenstein. *B*—Northern Spy, McIntosh, Golden Russet, Wagener, Rhode Island Greening, Baldwin, Fameuse.

New Brunswick and Quebec

A—Oldenburg, Alexander, Wolf River. *B*—Northern Spy, McIntosh, Fameuse.

2. Peach Regions and Varieties

Peach districts are identical in many cases with apple districts. They do not, however, extend into the colder apple sections, and on the other hand they go beyond the southern reaches of the commercial apple industry. At the northern limits of peach culture, orchards are often located adjacent to large bodies of water with their tempering climatic influence. The peach belts of New York along the shores of Lake

Ontario and in Michigan bordering the lake of the same name are illustrations.

Elberta is the main crop peach at the present time. There is great need of other varieties possessing the good features of Elberta, but of higher quality and extending the season in both directions. Considerable effort is being expended to develop such varieties. The New Jersey Agricultural Experiment Station and the Horticultural Experiment Station at Vineland, Ontario, Canada, have already introduced or developed several varieties of much promise.

Freestone varieties with yellow flesh are preferred by the public as fresh fruit.

The Far West prefers yellow clingstone peaches for commercial canning. Many of the early varieties have white flesh. The white-fleshed varieties as a group appear to be more hardy and resistant to cold than the yellow varieties.

The usual commercial orchard consists of two or three varieties in addition to Elberta; an orchard supplying a local market or a roadside trade requires a more extended list.

With the expansion of the southern peach areas, some of the northern districts whose crops reach the markets late in the season are declining in importance.

South Haven, Hiley, Belle of Georgia, J. H. Hale, Golden Jubilee, Vedette, and Howard Fisher are some of the popular varieties in the Northeastern section.

California is the largest producer of peaches, both in quantity and value, of any section of the country. Fruit is grown to be marketed in the fresh state, as in other sections, but large quantities are also produced for canning and drying. The bulk of the California crop is processed in one way or another before being put on the market. Numerous varieties, however, are grown to be sold in the fresh state. Although Elberta is grown, it is much less important in California than in other commercial sections.

In the extreme South, including parts of Florida and Louisiana, conditions are not adapted to the races of peaches to which most commercial varieties belong, the North China and the Persian. Here varieties of the Peen-to and South China races are grown, but not as factors in a commercial sense.

3. Pear Regions and Varieties

California and New York are the principal pear districts of the country. Other sections where the industry has attained commercial status are New Jersey, Michigan, Delaware, Maryland, Colorado, Washington, and Oregon. Fire blight is the chief enemy of pear culture in most sections, and the industry is dying out in some districts because of its inroads.

Bartlett is the standard variety both for the fresh-fruit market and for canning. Clapp Favorite, Anjou, Seckel, Bosc, Angouleme (Duchess), Clairgeau, Lawrence, and Kieffer are also grown in New York, New Jersey, and Michigan, to a limited extent. Kieffer is much more important in New Jersey than in New York, and is the leading variety south from New Jersey. Other varieties of the Kieffer type, of commercial importance in the same districts where Kieffer is the leading variety, are Le Conte and Garber. Gorham is a new New York variety which is being recommended very highly.

Bartlett is almost the sole variety in California. In Washington and Oregon the planting list is much the same as in the East, omitting Seckel but adding Comice, Howell, Hardy and Winter Nelis.

4. Cherry Regions and Varieties

Sour cherries are grown commercially in western New York, the Hudson Valley in the same state, western Michigan, Ohio along the shores of Lake Erie, in the Arkansas River Valley in Colorado, in limited areas in Wisconsin and Iowa, and to a less extent in other states.

The industry is built around Montmorency as the main crop variety with Early Richmond to open the season and English Morello to extend it beyond Montmorency. Ostheim, Dyehouse, and Large Montmorency are grown to a limited extent.

Sweet cherries reach their highest perfection and their greatest yields, and are most largely grown, in the Pacific Coast states. They are also grown commercially in western Michigan, western New York, and the Hudson River Valley. They are less hardy than the sour cherries and short-lived in sections not well adapted for them.

Bing, Lambert, and Napoleon are the chief varieties in the Pacific Northwest. The first two varieties are shipped as fresh fruit; Napoleon is sold in the fresh state, but is used more extensively for canning. These three varieties are both self-sterile and intersterile. They should be planted in connection with other varities as indicated in Chapter VIII, "Pollination."

East of the Rocky Mountains, Black Tartarian, Windsor, Schmidt, Napoleon, and Yellow Spanish are the leading sweet varieties.

5. Plum Regions and Varieties

Aside from the prune sections on the Pacific Coast, plum culture is not carried on in clearly defined areas, but is common in a limited way to nearly all sections of the country. In the colder sections as the Dakotas and the Great Plains area, varieties derived from the native species do best. They are excellent for preserves and cooking, but less desirable to eat in the fresh state. In the lower Mississippi Valley the native and Japanese varieties do well. From the Potomac River south to the Gulf Coast and west in Texas, native, Japanese, and hybrid varieties occur. The Damson plums are popular in many sections for culinary use. In the eastern states, the European plums are of major importance, but Japanese varieties are also grown, among them Abundance and Burbank. In California and to a less extent in other sections where the climate is suited to peach growing, the Japanese varieties do well, though European varieties of both plums and prunes are important in the Pacific Coast states. Secure the recommendations of the local experiment station. Some promising new varieties have been developed.

6. Quince Regions and Varieties

New York, Ohio, and Pennsylvania are the sections in which the quince is produced in commercial quantities. The demand is not large. The fruit is used chiefly for jellies, for which it is highly valued. Some growers are doing very well with this fruit, but the market may easily be over-supplied. Fire blight is often destructive, especially to young plantations.

The chief varieties are Orange, Champion, Rea, Meech, Pineapple, and Bourgeat. It is probable that Orange is a group rather than a variety name.

7. Apricot Regions and Varieties

California is the seat of commercial apricot culture, though this fruit is grown in a limited way in many states. The blossoms open early in the spring, and frosts are often a limiting factor in its culture. Although the fresh fruit of many varieties is desirable, the apricot is used chiefly for drying and canning.

Blenheim, Moorpark, Royal, Tilton, and Newcastle are the chief varieties in California. Breda and Harris are desirable in sections where hardiness is a prime factor.

8. Stocks for Fruit Trees

There is great variation in stocks for fruit trees, and great need of studies to determine the best stock to use for given conditions. Some important experimental work in this field is being done by the New York Agricultural Experiment Station and should be watched closely.

At present, the wild French Crab furnishes most of the stocks for apples. It comes not only from France but from all Central Europe and is exceedingly variable. Many apple seedlings are now grown in the United States. Dwarf apples are grown on the stock of the wild Paradise apple, and semi-dwarf trees on stock of the Doucin apple, both from European sources.

Pears are grown on wild French pear seedlings; Japanese and Chinese stocks for pears are on trial. Dwarf pear trees are grown on quince roots.

The quince is commonly grown on stock of the Angers quince, a variety which is worth little except as a stock.

The cherry is budded on stocks of the Mazzard and Mahaleb cherries. Mazzard stock has come mainly from Europe in the past but is now being grown extensively in this country also. In some cases seedlings of cultivated sweet cherries are sold as Mazzard stock. This causes much variation in the results secured. Under favorable conditions Mazzard stock gives a larger tree of longer life than does Mahaleb. The stock is more susceptible to leaf spot, however, than the Mahaleb. It is more difficult to secure a good stand of buds in the nursery. Mahaleb roots are more hardy and will succeed under more diverse conditions than Mazzard and are less expensive for the nurseryman to grow. In the East, at least, growers should insist upon sweet cherries on Mazzard roots and should expect to pay more for them. In the West, the Stockton Morello is used as a dwarfing stock for cherries. Sweet cherries on Mahaleb roots are often short-lived, and although sour cherries grow quite satisfactorily on Mahaleb roots, recent evidence indicates that they also will thrive better on the Mazzard stock.

The peach is grown on stocks from pits of the wild peaches of Tennessee and the Carolinas, and from the seeds of cultivated varieties. The former are preferred. Plum stocks are sometimes used for standard trees to be planted on heavy land.

Myrobalan stock of European origin is used almost entirely in the East for plums. In the colder sections plums are worked on the hardy native plum species. St. Julien plum stock from France is also used to some extent for plums, the claim being that it produces longer-lived, hardier trees. The Marianna plum stock is used in parts of the South. Peach stocks are used sometimes for plums on warm sandy soils, especially for the Japanese or Salicina varieties.

COMMUNITY STUDIES

1. Visit several leading growers. Determine:

    a. Nature of market served.
    b. Varieties grown in order of importance.
    c. Varieties used for fillers.
    d. Ages at which varieties come into commercial bearing.
    e. Growers' estimate or records of production and value of varieties.
    f. Source from which trees are obtained.
    g. Age and grade of trees purchased.
    h. Location of orchards with respect to soil types, elevation with respect to surrounding area, soil and atmospheric drainage, and direction of slope.
    i. Planting season.
    j. Method of preparation of soil.
    k. Planting plan and distances.
    l. Arrangement of labor for planting.
    m. Method of planting the trees.
    n. Are varieties set in solid blocks or alternated through the orchard?

2. Check varieties grown against recommendations of the local experiment station for the region.

3. Check varieties grown from the standpoint of pollination.

4. Prepare a cost statement for establishing a 50-acre orchard including all factors from the preparation of the field to the planting of the trees.

CHAPTER IV

GROWTH OF THE TREE AND THE FORMING OF FRUIT BUDS

A thorough knowledge of tree growth, including fruit spurs, fruit and leaf buds, is necessary in order properly to spray and prune the trees, thin the fruits, and fertilize and manage the soil.

Procedure:

(*a*) Consider different kinds of tree growth.
(*b*) Determine when length growth ceases.
(*c*) Determine when growth in thickness ceases.
(*d*) Study and determine the location of leaf buds, fruit buds, and fruit spurs.
(*e*) Consider the fruiting habits of different fruits.
(*f*) Determine the time and manner of fruit-bud formation.

(*a*) *Consider Different Kinds of Tree Growth.* Growth takes place following the dormant period in the form of: (1) new leafy shoots over the tree; (2) blossoms and fruit formation; (3) new spurs (with such fruits as the apple, pear, cherry, plum, etc.); (4) an increase in growth of the old spurs; (5) bud formation; (6) an increase in the circumference of the limbs, branches, roots, and trunk; (7) new root growth.

The large number of new shoots over the tree is the most easily seen evidence of growth. The shoots growing from the terminal buds are usually called terminal growths. Thus one often hears growers remark that their trees have made as much as 6, 10, 12, or more inches of terminal growth during a single growing season. The number and lengths of terminal growths can be used as one measure of tree growth, although their thickness and also the increase in the diameter of the branches, spurs, and trunks should also be considered.

(*b*) *Determine When Length Growth Ceases.* The time at which length growth ceases varies with the different fruits and with several other factors. Thus it is common knowledge that peach trees normally continue growth in length much later in the season than apples, pears, or European plums. The length of the growing period for terminal shoots varies with many factors such as: (1) age of tree, (2) rainfall, (3) summer heat, and (4) to some extent with pruning and soil fertility.

Vigorous, young trees normally continue terminal growth later in the season than old trees. In seasons of abnormally heavy rainfall growth may continue much later than in years of normal rainfall. Trees which have been pruned heavily usually grow later in the season than lightly pruned trees. Heavy applications of nitrogenous fertilizers, especially if moisture is abundant, also generally cause trees to grow much later than usual.

The rate of terminal growth is very rapid early in the season; it gradually slows down and finally ceases. In most years, length growth is completed by the first to the fifteenth of July, at least in the northeastern and central-eastern states.

(*c*) *Determine When Growth in Thickness Ceases.* Limbs, trunks, roots, and other parts increase in thickness and may continue such thickening for a considerable period after length growth of shoots has ceased. As long as the bark will peel readily, the cambium cells (the thin layer of actively growing tissue just inside the bark) are probably still dividing and growth is continuing. Branches and roots apparently increase in thickness even after the cambium cells have ceased to divide.

(*d*) *Study and Determine the Location of Leaf Buds, Fruit Buds, and Fruit Spurs.* Buds on fruit trees are produced in the axils of the leaves on the sides of shoots and spurs (lateral buds) and at the tips of shoots, spurs, and branches (terminal buds). Leaf buds are those from which a branch or spur may grow, and are often more slender and pointed than fruit buds. Fruit buds contain the unopened flowers, and often rudimentary leaves as well. Fruit buds of the peach, apricot, cherry, and plum contain flower parts only, while those of the apple, pear, and quince contain both leaves and flowers.

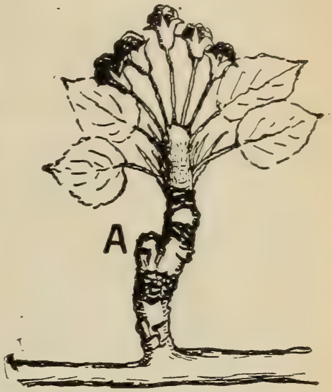


Fig. 70. Blossoming apple spur starting its fourth year's growth. An apple has been borne at *A*.

Fruit buds are frequently borne on very short growths or branches called fruit spurs. The fruit spurs of apples and pears are readily apparent by reason of their characteristic short, crooked, and roughened appearance. Fruit spurs of the apple and pear normally make only a short growth each year, and the same spur generally bears fruit only in alternate years. When a spur blossoms, a thickened cluster base bearing the blossoms and several small leaves is formed (Fig. 70). Five blossoms usually occur in a cluster, though the number varies from three to eight. New growth of the spur then usually proceeds from a leaf bud in the axil of one of the small leaves on the side of this cluster base. This side growth is usually spoken of as a "secondary growth," but may consist of only a small side bud. This then explains the crooked appearance of such fruit spurs. Usually a leaf bud is formed at the terminal of the secondary

Fig. 71. Four-year-old apple spur. This spur fruited at *A* and secondary growth from the cluster base extended to *B*, terminated by a leaf bud. The next year a straight growth was made which formed a terminal fruit bud.

or side growth, especially if the blossoms "set" fruit. The next year this leaf bud, on the secondary growth usually makes a straight growth, and then a fruit bud which blossoms the following spring is formed at its terminal (Fig. 71). Thus the same spur normally bears fruit only every other year.

Fruit thinning after the June drop then would hardly be expected to cause fruit buds to form again on such spurs for the next year's crop. It will also be seen, later in the chapter, that by the time most fruit thinning is done, fruit-bud differentiation for the next year's crop is well under way. Fruit spurs generally complete their growth in length for the year within two weeks after blossoming, although increase in diameter continues over a much longer period.

Fig. 72. A six-year-old apple spur which has never blossomed or borne fruit.

The age of spurs can readily be ascertained by observing the "rings" caused by the scars left where the bud scales have fallen off. It is easy to determine whether the spurs have been productive or whether they have never borne by looking for the cluster bases, or for scars made where the stems of fruit were removed from the spur. See Fig. 72. To be productive, spurs should make a fair amount of new growth each year and have a good supply of healthy foliage.

(*e*) *Consider the Fruiting Habits of Different Fruits. Apple and Pear.* Much of the fruit is borne on spurs in the apple and pear, although in certain varieties considerable fruit is often borne laterally and terminally on one-year-old wood. Fruit spurs are normally produced more abundantly on certain varieties than on others.

In some apple varieties, as Oldenburg, Jonathan, Rhode Island Greening, and Wealthy, the spurs often develop fruit buds during the same year that the spurs are formed. Such varieties thus bear considerable fruit each year on two-year sections of wood (or one-year spurs) even while the trees are young (Fig. 73).

Older bearing trees of practically all varieties, at least in Eastern fruit regions, bear on two-year-old sections of wood (one-year-old fruit spurs) in the heavy-crop year, but not in the light-crop year.

Many varieties of apples such as York Imperial, Winesap,

FIG. 73. Young bearing trees of Oldenburg (left) and Wealthy (right). Note that spurs of all ages including the one-year-old spurs are blossoming. The lateral buds on the one-year-old shoots and the terminal buds are also blossoming. Biennial bearing trees as York Imperial and Baldwin usually blossom in this same way in the heavy-crop year.

Arkansas, Baldwin, Wagener, and Stayman Winesap often form terminal and lateral fruit buds in the year when the trees have practically no crop. Such buds blossom the following year when the whole tree is blossoming heavily, but often do not set fruit, especially on the lateral buds, unless the blossoms on the spurs fail to set. These same varieties, however, seldom form terminal and lateral fruit buds to any extent in the crop year.

Other apple varieties as Wealthy, Jonathan, and Oldenburg, and pear varieties as Bartlett and Winter Nelis, at least in New York, Maryland, and Oregon, do produce a large amount of fruit each year from terminal and axillary or lateral buds on one-year wood, particularly while the trees are young or are especially vigorous. Under such conditions fair annual crops are produced.

Fig. 74. Peach shoot showing triple bud at *A*. Other buds shown are side views so only one of the buds is shown at each node.

Some apple varieties, as Ben Davis, Gano, Rome, Winter Banana, Yellow Transparent, and Golden Delicious bear much of their first few crops on terminal buds of the shoots unless, through incorrect pruning, these buds are removed by "heading in" the terminal growth.

The fruit spurs of pears very closely resemble those of apples in growth and bearing habit.

Peach and Apricot. The peach and apricot produce lateral fruit buds on the new shoots and to some extent on short growths, which are sometimes called spurs: In the peach most of the crop is borne on so-called "one-year growth." It will be recalled that with apples much of the fruit is borne on spurs. Of course, as pointed out previously, the wood of apple spurs, upon which fruit buds are borne, is also only one year old. On the vigorous shoots of peach trees, three buds are generally formed at nearly every node. See Fig. 74. The two outside buds which usually are well rounded and plump in appearance are fruit buds, and the center, rather pointed bud, as a rule, is a leaf bud. Each bud is formed in the axil of a leaf, so that three leaves appear to be formed at each node. As a matter of fact a close study of the true condition will show that the two-fruit bud leaves are really borne on very short branches in the axil of the main larger leaf. On weaker growths, only single-fruit buds or leaf buds may form, and this condition often occurs near the ends of shoots of low vigor.

Apricots usually produce more fruit on so-called "spurs" than do peaches. Each fruit bud on the peach and apricot generally opens into a single flower.

Plum. The plum produces fruit buds in a lateral position on shoots and on fruit spurs. The European or Domestica, and Insititia plums represented by such varieties as Italian prune and Shropshire Damson, respectively, usually bear most of their fruit on spurs. In general, the fruit buds are borne laterally about the spur, and a leaf bud in the axil of a single leaf is produced approximately at the spur terminal. As a result, plum spurs generally grow straighter than spurs of the apple. Some fruit is also borne laterally on the one-year shoots as with the peach, but this is more common with the Japanese plums.

With the Japanese varieties such as Abundance and Burbank, fruit buds are borne laterally on both one-year shoots and on spurs. The tips of both shoots and spurs are generally terminated with a leaf bud. In contrast to the Domestica and Insititia plums, these Japanese plums usually bear heavily on the one-year shoots, like the peach. The fruit buds borne on the shoots may be single or associated with a leaf bud, or sometimes with a leaf bud and another fruit bud as in the peach. Occasionally the fruit buds occur in clusters. Fruit buds on the spurs occur either singly in the axils of the leaves or often in lateral clusters similar to the cherry. Each fruit bud generally produces from one to three flowers.

Cherry. The cherry produces lateral fruit buds on one-year shoots and on spurs. Leaf buds terminate the shoots and nearly always the spurs. As a result, growth of the spurs is generally continued each year from their terminals, thus resulting in relatively straight spurs. With sweet cherries much of the crop is borne on spurs, although some fruit is produced laterally on one-year wood. On trees making a vigorous terminal growth, few lateral fruit buds are found on the one-year growth, however, and these are generally near the base. The spur fruit buds may occur singly around the spur, but often are found in a whorl or cluster about the terminal leaf bud.

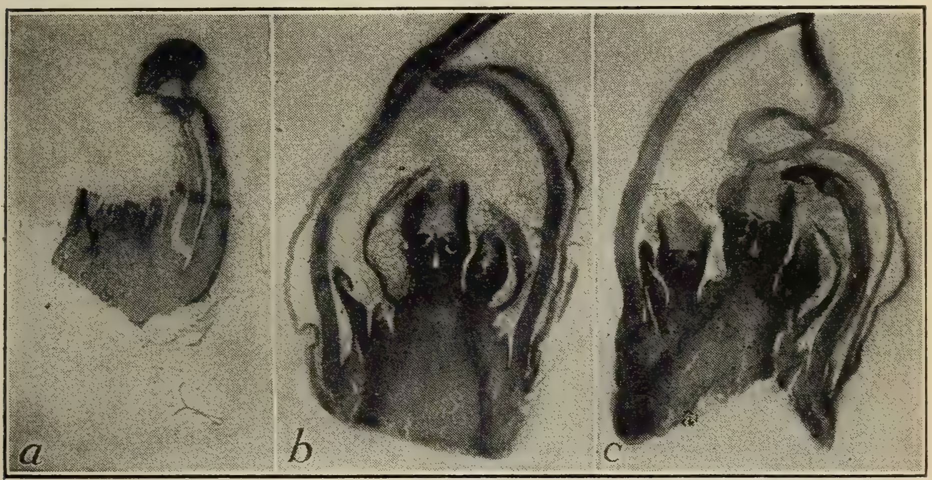
With sour cherries, fruit buds are freely produced on both fruit spurs and one-year wood. On terminal growths up to 7 or 8 inches, nearly every lateral bud is a fruit bud. As a result, sour cherries produce a great deal of fruit on one-year wood, like the peach and Japanese plum, although the fruit buds appear singly in the cherry. If all the lateral buds on cherry shoots are fruit buds, no leaf buds are then available from which new spurs can be developed, and this wood remains bare of spurs and fruits in the future. It is thus advisable to produce vigorous shoots on the cherry, so that some of the lateral buds formed will be leaf buds from which fruit spurs can develop. Trees with a good spur system generally produce more fruit and the spur buds are more resistant to cold. Fruit buds on the spurs occur singly or in clusters. Each fruit bud usually produces from one to three flowers.

Quince. The quince produces terminal and lateral fruit buds on one year-wood. Growth from the fruit buds is somewhat different from that of the fruits previously described. Instead of opening into a short cluster base with several blossoms, like the apple, the terminal fruit bud of the quince, makes a short, leafy, growth of one to several inches, and a single flower is then unfolded. Lateral fruit buds formed on the shoots of the previous season's growth may also produce short growths and then blossom. Fruit buds for the next year's crop are produced terminally and laterally on short growths, which arise from either the bearing or non-bearing shoots.

(*f*) *Determine the Time and Manner of Fruit-Bud Formation.* Fruit buds are formed the year previous to their opening. At some time during the early summer, after the buds are formed, differentiation occurs inside of the buds which determines whether a bud will remain a leaf bud or become a fruit bud. With some fruits, buds may contain both leaves and flowers.

Apple. In general, differentiation in the apple starts about the last part of June or the first part of July, but some buds are differentiated later in the season.

The exact time of differentiation varies somewhat with the variety, locality, pruning and fertilizer treatment, season, and other factors. Not all buds on the tree differentiate at the same time. Normally spur buds are the first to differentiate,

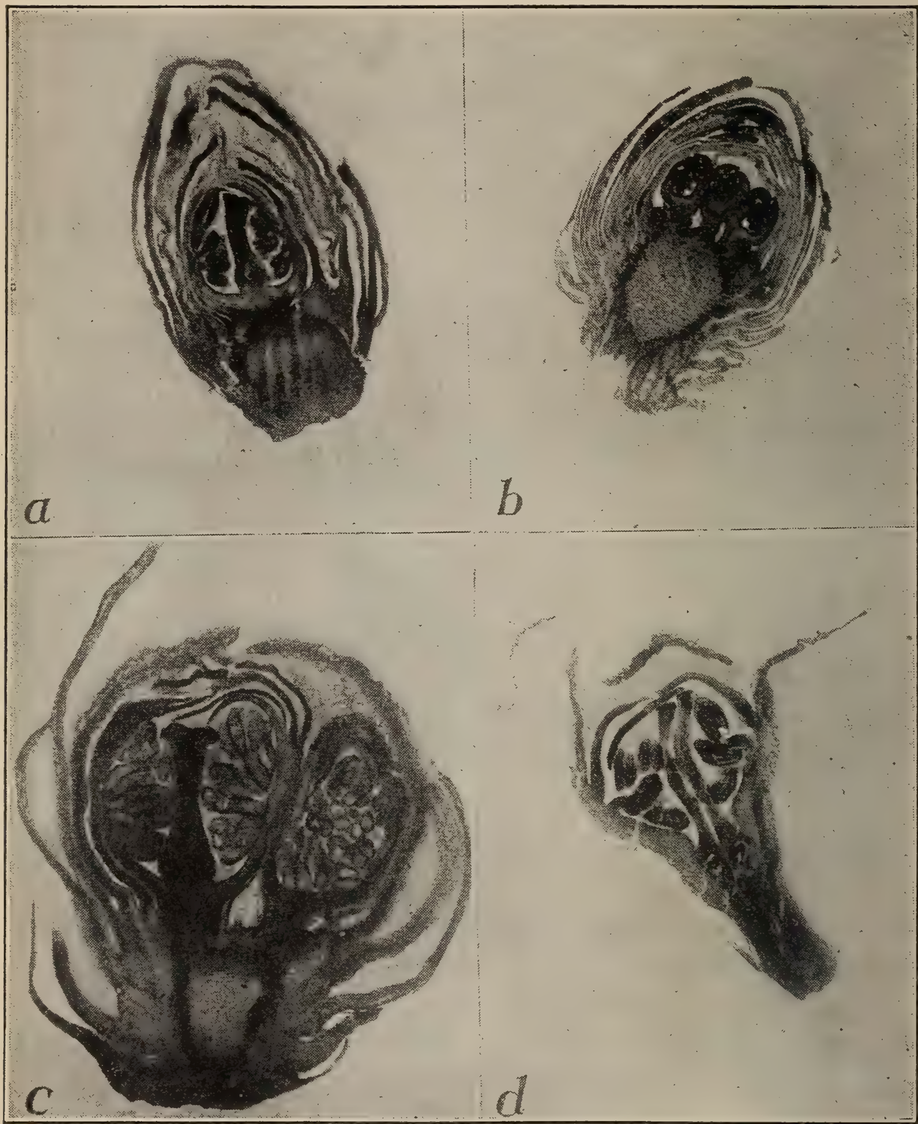


(*Virginia Exp. Station*)

Fig. 75. Showing differentiation and development of flower buds of the Oldenburg apple in Virginia. (*a*) June 30. (*b*) October 21. (*c*) January 6.

followed about three weeks later by the lateral buds, and finally by the terminal buds at the ends of the shoots.

The sepals are generally the first noticeable parts to develop, and these are commonly followed by the petals, stamens, and pistils in the order named. Thus there is a gradual development of the various parts throughout the summer, and by the latter part of October the various parts of the flower within the bud are quite distinct (Fig. 75). Only minor changes occur during the winter, but the cells (pollen mother cells), from which the pollen is eventually formed, gradually



(*Virginia Exp. Station*)

Fig. 76. Showing advanced stages in the development of flower buds of the peach, plum, cherry, and pear: (*a*) peach bud, January 6; (*b*) plum bud, January 20; (*c*) cherry bud, April 1; (*d*) pear bud, March 17. Note that all the flower parts are developed and simply await the opening of the buds to expand into flowers.

develop, other changes occur, and toward spring the ovary enlarges and ovules are formed. By early spring all the flower parts are developed and simply await the opening of the buds to expand into flowers.

Pear. Differentiation in the pear usually starts about the middle of July and proceeds much the same as in the apple. The order of differentiation of the different fruit buds is likewise quite similar to that of the apple.

Peach. Most investigators report that the first noticeable differentiation in the peach occurs in the latter part of July.

Plum and Cherry. The time of differentiation seems to vary somewhat with the different species of plums. Thus varieties of the Americana species differentiate about the first week in July, those of the Japanese plums about the second week in July, and one variety at least of the Hortulana species, the Whitaker, a wild goose plum, showed no sign of fruit-bud differentiation in Virginia until the first week in September. Cherry buds seem to differentiate about the first week in July.

Quince. In Wisconsin, observations seemed to show that the beginning of flower parts could first be seen in the quince during late summer or early autumn.

Summary and Conclusions Concerning Fruit-Bud Differentiation. It can be seen that most fruit buds are formed normally quite early in the season. Thus it seems reasonable that any treatments such as fertilization, pruning, and soil culture, designed to influence tree growth and fruit-bud formation, would be more effective if given in the spring and early summer.

It should also be kept in mind that the fruit buds are formed the year preceding that in which the crop is borne.

TREE PHYSIOLOGY AND NUTRITION

Fruit trees as well as other plants grow, thrive, and are productive when adequate amounts of water, mineral or soil foods, and air foods are available, provided that other environmental conditions are satisfactory. The plants absorb from the soil, through the fine root hairs, the various mineral elements. These, of course, must be dissolved in the soil water before they can be absorbed, and are taken into the plants through the roots. Nitrogen, phosphorus, potassium, calcium, sulfur, iron, and magnesium seem highly essential for most plants, but other elements, including silicon, chlorine, sodium, manganese and aluminum are also used. See also the reference to cases of boron deficiency at the close of the chapter on managing orchard soils and fertilizing the trees, page 440.

What Elements Are Most Often Lacking in the Soil. Although fruit trees do need and use for proper development all the essential elements, experiments have shown that most soils are supplied with sufficient available amounts of these minerals for satisfactory tree growth and fruitfulness. Sufficient nitrogen for best growth and fruiting, however, seems to be lacking in many soils, and in such cases much better growth and production result whenever it is added.

How Trees Live and Function. In the leaves, and to a small extent in other green tissue, various elaborated or digested foods are formed. This process occurs in the presence of sunlight in the green parts or chloroplasts of the leaves. Carbon dioxide of the air enters through small breathing pores or stomata, and is combined with water to make up certain elaborated foods called carbohydrates (starches, sugars, etc.).

Since food and water are also combined and digested in the stomach of a person, the leaves might be called the stomach of the plant. With these facts in mind the great value to the plant of having a large, green, and healthy leaf surface can readily be seen.

The soil foods may be considered as raw foods. After being taken into the plant and combined with the carbohydrates, or other elaborated materials formed from them, they help to make up certain other foods. Of these foods, the carbohydrates and proteins are very important. The carbohydrates, proteins, and other materials derived from them are formed into new tissues and are also used in strengthening other tissues. Thus, in the apple, these materials are used in: (*a*) making new terminal growth over the tree; (*b*) increasing the diameter of the main limbs, trunks, and roots; (*c*) the production of new root growth; (*d*) the formation of new fruit spurs; (*e*) keeping the old spurs healthy; (*f*) the formation of fruit buds for fruit production; and (*g*) developing the individual fruits.

Carbohydrates Are Essential for Fruit-Bud Formation. The accumulation of carbohydrates in the tissues is generally small during rapid growth, since the carbohydrates are largely used in building and developing new tissues, if the supply of moisture and nitrates is abundant. When rapid growth ceases, carbohydrates accumulate and at this time, or shortly thereafter fruit buds begin to differentiate.

Ringing and Notching. Additional evidences showing the favorable effects of carbohydrate accumulation on fruit-bud formation is found in ringing and notching. When vigorous young trees are ringed (a narrow ring of bark removed from the trunk without injury to the cambium layer) in May or early in June, such trees usually form a large number of fruit buds for the next year's crop, owing to the accumulation of carbohydrates above the ring. In ringing, a section of the tissue (phloem) through which the carbohydrates are translocated to the lower parts of the tree and roots is removed, and as a result the concentration of carbohydrates is greater in the tops of the trees.

Where whole trees are ringed by removing a strip of bark around the trunk, a dwarfing of the trees often results. The roots are cut off from their full supply of carbohydrates and accordingly are checked in growth. This, together with the dwarfing caused by the crop of fruit, makes the practice questionable when several years are considered.

It is probable that more satisfactory results would occur over a period of years if ringing were confined to one main limb on the tree each year. By this means some fruit would be produced at an earlier age, and the trees would not receive such a general check in growth.

On the same principle as ringing, if a notch is cut in the twig below a bud, carbohydrates accumulate above the bud, and a fruit bud generally forms. A notch cut above a bud, thus decreasing carbohydrate accumulation and increasing the supply of nitrogen in the bud, will force out a shoot from that bud.

Removal of Leaves Decreases the Carbohydrate Supply and Reduces Growth. In case of such removal fruit-bud formation is also decreased, or, if differentiation has already occurred before the defoliation, the development of the buds is delayed, and they are often weakened. The removal of leaves from a spur or from a lateral bud usually prevents the formation of fruit buds at these places. Thus each bud or spur is more or less dependent for its carbohydrates upon its own leaves. No doubt there is some translocation of food materials, however, from one region to another in a shoot or branch. It is known, for instance, that apples will develop normally even though there are no leaves immediately adjacent to them.

By Addition of Nitrogen, Tree Growth and Fruit-Bud Production Are Often Greatly Increased. In many orchards in which growth has been checked by the lack of nitrogen, even though an accumulation of carbohydrates has resulted, fruitfulness has not prevailed. Under such conditions remarkable results are secured in growth and fruitfulness from the application of nitrogenous fertilizers. When nitrates become available, the stored carbohydrates are utilized, new growth results throughout the tree, the foliage becomes larger and greener, and large numbers of fruit buds are usually formed.

Great Importance of Water in Tree Growth and Successful Fruit Growing Cannot Be Overemphasized. The absolute dependence of the tree's welfare on water can readily be seen from the fact that all soil nutrients must first be dissolved in water before they can be taken into the plant. These soil nutrients, however, do not flow into the plant in a water stream, but their intake depends upon their solubility and their relative concentration within and without the plant. Whenever their concentration is higher in the soil solution, they diffuse into the plant. If it were not for water, these foods would not be transported up through the plant. Water, again, is necessary in the formation of the carbohydrates, proteins, fats, etc., and their translocation down from the leaves to all parts of the branches, fruit, trunk, and roots. Large amounts of water are likewise transpired daily. About 500 pounds of water are transpired for each pound of dry matter produced, and fruits contain from 85 to 90 percent water. Such troubles as cracking of fruit, water core, fruit pit, cork, drought spot, and die-back are all exaggerated by improper water relations. Each vigorous, mature apple tree uses from 15 to 20 tons of water per year when it is making a good growth and producing a good crop.

On the other hand, it is possible to have too much soil moisture available for good tree growth and fruitfulness; then trees suffer from what is commonly known as "wet feet." Orchards planted in ground that remains wet during most of the year, especially if the water table is close to the surface, grow and fruit very poorly, and are easily injured by cold weather. Such soils are poorly aerated and do not warm up, bacterial action in the soil is practically prevented, and the roots of fruit trees either make very little growth or die. Of course orchards should not be planted under such conditions, but they are occasionally found. If the conditions are not too hopeless, thorough soil drainage will produce wonderful results.

Relation of Amounts of Carbohydrates and Nitrogen. Not only are the amounts of carbohydrates and nitrogen important in influencing growth and fruitfulness, but the relative proportions of these in the plant seem to be very important.

In general, plants may be grouped into four classes, depending upon their growth and fruitfulness, and the proportion of carbohydrates and nitrogen in their tissues.

The four classes are as follows:

Class I. If the supply of moisture and nitrogen is abundant, but that of carbohydrates is restricted, growth will be weak, slender, and feeble, and there will be little or no production of flowers. Although this condition is not common in orchards, it might occur if trees were defoliated yearly by insects, diseases, or spray material. Trees pruned heavily in the summer would probably fall into this group also.

Class II. If the supply of moisture and nitrogen is abundant, and there are sufficient carbohydrates to utilize this nitrogen supply, a strong, vigorous wood and leaf growth results, but still very few fruit buds are formed. The carbohydrates are used in growth, leaving no surplus for fruit-bud formation. This condition is well illustrated by vigorous, rather heavily pruned young orchards, which continue to grow vigorously, on rich, moist, fertile, cultivated soils, but do not come into bearing.

Bearing apple trees which have been too heavily pruned and headed back in the dormant season usually fall into this class for two or three years after the pruning. The carbohydrates stored in the limbs, spurs, etc., are cut away in the pruning, resulting in an unusually large supply of nitrogen and water for those buds which remain. The removal of so many buds also reduces greatly the amount of growth and leaves which normally would have been produced. Thus, less carbohydrates would be made and stored.

Class III. If the moisture and nitrogen supply is ample, and there is an excess of carbohydrates over and above the amounts utilized with the nitrogen, there is not only a good growth of tree, but also an abundant supply of fruit buds. This is the condition found in healthy, producing orchards.

Class IV. If there is a deficiency of nitrogen and an abundance of carbohydrates, an extremely weak growth, yellowish foliage, with either few flowers produced or else a production of flowers too weak to set fruit results. This is the condition usually found in so-called "starved" or "devitalized orchards."

Old orchards growing under sod conditions, without fertilization, are often in this class.

If we were to represent these conditions graphically, illustrating the amounts and relations of carbohydrates and nitrates by sizes of letters, the chart would look as follows:

Class I. $\frac{\scriptstyle C}{\Large N}$ Poor growth. Small amount of fruit.

Class II. $\frac{C}{N}$ Rank growth. Small amount of fruit.

Class III. $\frac{\Large C}{\scriptstyle N}$ Fair growth. Good fruiting.

Class IV. $\frac{\LARGE C}{\scriptscriptstyle N}$ Poor growth. Small amount of fruit.

It can thus be seen that both carbohydrates and nitrogen are very important for tree growth and fruit production. An accumulation of carbohydrates alone, if caused by a lack of nitrogen or some other limiting factor, would probably not cause either growth or fruit-bud formation. A supply of nitrogen would then be necessary in order to have the carbohydrates utilized. Likewise a large supply or accumulation of nitrogen would not cause growth and fruiting in the absence of an adequate supply of carbohydrates. Such common orchard operations as pruning, fertilization, and soil management should therefore be considered in relation to their effect on the carbohydrate and nitrogen supply of fruit trees, before deciding upon any definite practices.

COMMUNITY STUDIES

1. Inspect several different kinds of fruit trees in your community. Determine:

   (*a*) Where the fruit buds are formed.
   (*b*) Where the leaf buds are formed.
   (*c*) The average length of terminal growth.
   (*d*) Whether fruit spurs are present.

2. Study a fruit spur. Determine:
   (*a*) Its age.
   (*b*) How many times it has borne.
   (*c*) The length of growth made each year.
3. Examine an apple tree. Determine:
   (*a*) What percentage of the spurs have never borne any fruit.
   (*b*) What percentage of the spurs are bearing fruit this year.
4. Examine different varieties of apple trees. Determine:
   (*a*) Whether fruit is being borne, (*b*) terminally on shoots, (*c*) laterally, or (*d*) terminally on spurs.
5. How old must a spur be before it will form fruit buds?
6. Determine at what time of year terminal growth in length ceases. Determine the same for fruit spurs.
7. Ring some five-year-old apple trees, and see if they blossom any sooner than trees which are not so treated.
8. Put some nitrate of soda around an old, unproductive apple tree and determine its effect on:
   (*a*) Color of foliage.
   (*b*) Length of terminal growth.
   (*c*) Length of fruit spur growth.
   (*d*) Amount of fruit buds formed.
9. Explain the results secured in Studies 7 and 8 from a carbohydrate and nitrogen relationship within the plant.

CHAPTER V

PRUNING

A certain amount of pruning is desirable with all fruit trees. The amount of pruning required varies with the kinds of fruit, their age, fruiting habits, and other factors such as soil management and fertilization.

Operations:

1. Deciding when the pruning should be done.
2. Determining how heavily the trees should be pruned.
3. Selecting the pruning tools.
4. Pruning the different tree fruits.
5. Determining pruning costs.

1. Deciding When the Pruning Should be Done. Experiments show that pruning may well be done at any time from leaf fall in the autumn until the buds start to grow in the spring. In some sections where the winters are unusually cold, if there is danger of winter injury to the fresh pruning wounds, it would be well, especially with peaches and other stone fruits, to wait until spring before doing the pruning. In general, if one had only a few trees to prune and plenty of help, the work might well be left until spring; otherwise pruning should start in the fall or winter. Wounds made just as growth is starting in the spring heal a little more quickly, but this would not be of enough importance to delay the pruning if there is much of it to do. Careful pruning experiments in this and other countries have shown, however, that, as a general rule, dormant pruning over a period of years has been more satisfactory, when measured by tree growth and fruit yields, than summer pruning. Young trees given approximately the same kind and amount of pruning in the summer as that given to similar trees in the winter have generally produced less new growth and slightly smaller trunks and root systems and have not borne any earlier or larger crops. As a matter of fact, in most of the experiments recorded, the yields from the summer-pruned trees have been less.

Certain types of summer pruning may occasionally be desirable. The pinching out of undesirable shoots just after growth starts in newly planted trees may be of advantage in forming a proper framework in young trees. Water sprouts or suckers in old trees may well be rubbed off in early spring. Young trees which appear to be quite dense usually "open up" well when their first crops are borne. It may be desirable to head back an occasional limb on a young tree during the summer simply to maintain a better-shaped tree.

2. Determining How Heavily the Trees Should Be Pruned. Although the general principles underlying pruning hold for trees of all ages, old bearing trees generally require heavier pruning than young non-bearing trees. Accordingly, it is well to consider separately the pruning of young and of old trees.

Procedure:

(*a*) Prune young non-bearing trees lightly.
(*b*) Prune young bearing trees lightly.
(*c*) Prune old bearing trees more heavily.

(*a*) *Prune Young Non-Bearing Trees Lightly.* The best results are usually secured by pruning young trees lightly. Experiments in this and other countries have shown that with young trees pruning is a dwarfing process. Such trees pruned heavily each year have smaller trunks and smaller main branches, make less total top and root growth, have fewer fruit spurs, come into bearing later, and bear smaller crops, at least for the first few years, than trees pruned lightly. This is illustrated by Table 36 from *Michigan Extension Bulletin* 148.

TABLE 36

EFFECT OF SEVERITY OF PRUNING ON SIZE AND YIELD OF APPLE TREES
Growth measurements made at 9 years from planting.
Yields are totals per tree for the 9-year period.

Variety and Pruning Treatment	Average Size of Trees			Yield per Tree
	Trunk Circumference	Tree Spread	Tree Height	
	inches	*feet*	*feet*	*bushels*
Duchess (Oldenburg):				
None	14.2	13.8	16.3	2.9
Light	13.7	13.3	17.0	1.7
Heavy	12.2	11.4	15.5	1.1
Grimes:				
None	15.3	15.3	16.8	4.4
Light	15.1	14.8	16.4	4.9
Heavy	15.6	16.3	16.0	3.1
Baldwin:				
None	17.7	17.6	15.6	1.8
Light	17.6	16.5	16.2	0.5
Heavy	16.7	15.4	14.6	0.4
Stayman:				
None	16.8	20.9	17.4	3.7
Light	16.4	19.7	17.2	2.8
Heavy	15.0	18.5	16.5	1.8
Northern Spy:				
None	17.3	14.9	17.9	0
Light	15.7	12.4	16.6	0
Heavy	14.1	11.4	15.4	0
Average of all varieties:				
None	16.3	16.5	16.8	2.6
Light	15.7	15.3	16.7	2.0
Heavy	14.7	14.6	15.6	1.3

Pruning, by causing a decrease in leaf area, dwarfs the tree and reduces fruiting. When some of the branches of a tree are removed by "thinning out" and those remaining are "headed back," a large number of buds which might otherwise grow are removed. This means that the leaf area of the tree is reduced in proportion to the severity of the pruning.

With the leaf area reduced, the amount of carbohydrates and other foods formed is greatly reduced also, and since these are the materials which cause top and root growth and fruit-bud formation, as explained in Chapter IV, it is apparent why heavy pruning would dwarf the trees and decrease fruit production.

With the reduced root growth resulting from the pruning, less top growth would be produced each year in the heavily pruned trees, and thus the dwarfing, in comparison to the lighter pruned trees, would be more pronounced each year as the pruning continued, at least until the lightly pruned trees were bearing heavily.

In spite of all this, pruning is an essential orchard practice. The tree cannot be permitted to grow at will. A strong framework is necessary to carry future crops. Fundamental weaknesses are best corrected while the tree is small. The emphasis, therefore, should be on pruning as little as possible in keeping with known objectives and especially before the tree has begun to bear.

(*b*) *Prune Young Bearing Trees Lightly.* More wood growth and fruit are produced, for the same reason as described in the preceding section, if young bearing trees are given light rather than heavy pruning. Although the tops of lightly pruned trees may appear a little thick, while bearing the first few crops, nevertheless the trees usually develop faster and produce heavier crops than trees pruned more heavily. On young bearing trees the fruit usually is of good size and color, even though the trees are lightly pruned. The amount of pruning may well be increased after two or three commercial crops have been borne.

(c) *Prune Old Bearing Trees More Heavily.* Old bearing trees somewhat low in vigor generally respond better to moderately heavy pruning than to light pruning. The tops of such trees gradually become filled with numerous branches which are thickly set with old and weak spurs. Relatively little new spur or terminal growth occurs, and the leaves are often small and yellowish in appearance. The buds on the spurs open into a whorl of leaves each year, but very little extension growth is made. The wood of such trees gradually becomes packed with carbohydrates in proportion to nitrates, and such trees approach the non-vegetative and unfruitful class described in Chapter IV. Either many of the fruit spurs cease forming fruit buds, or, if buds are formed, many of the blossoms fail to set.

With such trees, moderately heavy pruning or much heavier applications of nitrogen fertilizers have a decidedly invigorating effect. If larger amounts of fertilizers are not added, heavy pruning will be especially beneficial. The pruning should consist primarily of making numerous small cuts equally distributed over the entire tree, so that all parts will be invigorated. The lower limbs, especially, should be well thinned out and in some trees it will pay to head back lightly an occasional slender, weak limb to an upward growing branch. An attempt should be made to keep these lower limbs growing and fruiting as well as those in the upper parts of the tree. The ends of the upper branches, where they are getting too high, should also be headed back to good laterals. This will tend to lower the tops and stimulate growth in the lower as well as upper branches.

As a result of removing numerous small branches containing large numbers of spurs and buds, the amount of carbohydrates will be reduced and more water and nitrates will be made available for each of the buds left. Terminal growth becomes longer, and those spurs which remain, including many which have not borne for years, make a longer growth, have larger and greener leaves, and form fruit buds.

Regular annual pruning should be practiced, in order to keep the trees open so that efficient spraying can be done, so that sunlight can reach all parts of the trees to assist in carbohydrate manufacture and the coloring of fruit, so that limb rub of fruit will be reduced, good growth assured in all parts of the tree, good size of fruit maintained, and so that the tops of the trees will not get too high.

3. Selecting the Pruning Tools. The kinds of pruning tools used vary in the different sections of the country. The tools most commonly found are saws, knives, hand shears, long-handled shears, and pole pruners.

Saws. In the West the swivel blade or meat saw type of saw, Fig. 77, *C, D, E,* is used to a great extent but it has never been universally adopted. In the East, many growers use a straight-bladed saw which is somewhat similar to a carpenter's saw but not so wide at the butt, with fewer points or teeth, Fig. 77, *G, H, I.* A satisfactory saw for general pruning is one about 2 feet long, 1 inch wide at the tip, and 4 inches wide at the butt, containing 6 to 7 teeth per inch. It should have a handle large enough to accommodate the entire hand with gloves on. Such a saw can be used even in narrow crotches and will be satisfactory for both small and large limbs. If it is necessary to make many large cuts, as often happens when renovating an old orchard, it will pay to have a forester's type of saw, which is heavier and has fewer and larger teeth. Such a saw cuts through the large limbs more easily and saves the energy of the man who is doing the sawing. The crescent-shaped type of saw, which cuts when the saw is pulled (Fig. 77*F*), is especially satisfactory for branches of medium size or where there is little room in which to use a saw. A two-edged saw should never be used in the orchard, as it is bound to cause injury to the bark. Shorter and narrower saws with pointed ends may be of value in young trees. Frequently, however, one can do as good a job and a much quicker one with a pair of hand shears.

Knives and Pruning Shears. For small trees, a heavy pruning knife with a long hooked blade is often used. A good, strong pair of pruning shears is indispensable, however, in pruning young trees (Fig. 77*A*). Most of the pruning with all fruits can be done for several years with such shears. Do not buy cheap shears, which are easily strained and

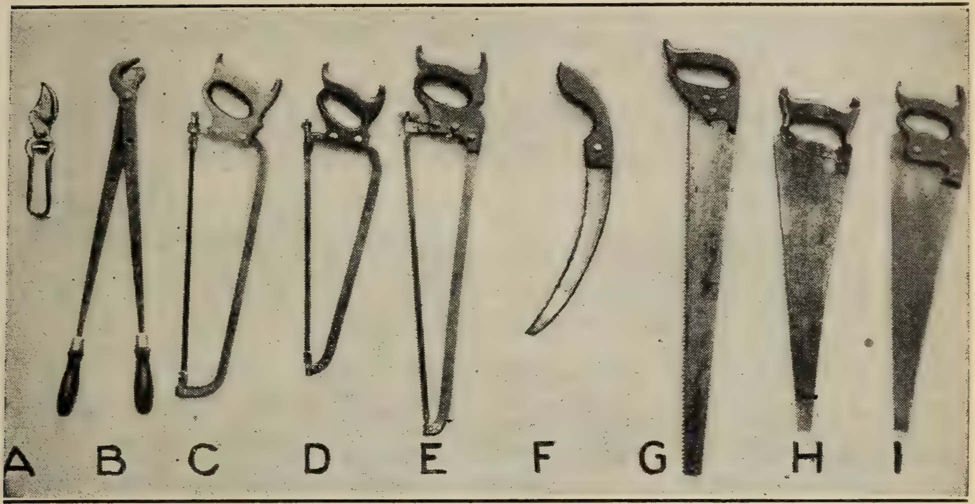


FIG. 77. Pruning tools used in the orchard. (*A*) Hand shears; (*B*) long-handled shears or "two-foots"; (*C, D,* and *E*) different patterns of swivel-bladed saws, popular in some regions but unpopular in others; (*F*) small type of pruning saw liked by many growers—the teeth slant toward the handle and cut when the saw is pulled; (*G*) straight-bladed saw, narrow at the point and not very wide at the handle—well liked by many growers; (*H*) ordinary carpenter's saw, not especially desirable; (*I*) carpenter's type of saw but made with larger, longer, and heavier teeth, especially valuable because of ease with which large limbs can be removed. A forester's saw, not shown in the illustration, is desirable, if many large branches are to be removed.

dulled; select those of good weight, containing the best steel blades.

Long-Handled Shears. Long-handled shears, commonly called "two foots" because the handles are about 2 feet in length, are of great value especially in peach and plum orchards. Much of the pruning can be done with such shears in all bearing orchards. Generally speaking the single-acting shears with wooden handles are not so satisfactory or powerful as the double-acting shears (Fig. 77*B*). There are, however, some very powerful, single-acting shears with steel handles and wood hand-grips that give excellent service. Many large limbs can be removed without the need of a saw and the work can be done as well and more quickly. The blade should be kept sharp and riveted down to make a clean, smooth cut.

Pole Pruners. Pole Pruners have only a limited use in orchard pruning. For ordinary cuts, which can easily be made with any of the tools already mentioned, pole pruners should never be used. They are awkward to handle, and it is difficult to make a close, smooth cut with them. Only when it seems desirable on young bearing trees to head back the centers of certain of the main limbs which cannot be reached from the ground are pole pruners of much value to the orchardist. In such cases they may be the most economical pruning tool that can be used. They should combine light weight and mechanical strength. Unless used carefully, the cutting blade becomes strained, or broken, causing much annoyance and loss of time.

4. Pruning the Different Tree Fruits. Since the amount and kind of pruning vary somewhat with the different tree fruits, it is necessary to consider the pruning of each kind separately.

The Apple

(*a*) *The Tops of Young Trees Should Be Pruned at Planting Time.* When nursery trees are dug, many of the roots are broken or cut off and left in the ground. Because of this greatly decreased root system, it will usually pay to prune the trees moderately after they are set. This will reduce the early leaf area in the spring and make it more nearly possible for the greatly diminished root system to supply sufficient water and mineral nutrients for satisfactory growth.

If one-year-old whips are planted, head them back to the height desired. Under most conditions 24 to 36 inches is a satisfactory height, but if the trees are to be pruned by the budding or pinching-out method as described under peach pruning, the whips should be left about 50 inches high. On well-branched two-year-old trees, all branches which are not desirable for framework branches should be removed and the others should be cut back, the amount depending to some extent upon the growth that they have made. Such branches should be left at least 16 to 18 inches long if possible, so as to allow plenty of room for secondary branches to grow and not be too close to the trunk. A higher percentage of the trees which are headed back usually live the first year, especially if it happens to be a dry season, because the roots have an opportunity to make some growth before much leaf area is expanded. Unless conditions are very satisfactory for rapid root growth and for low transpiration, limbs which are not headed back usually leaf out but make very little extension growth.

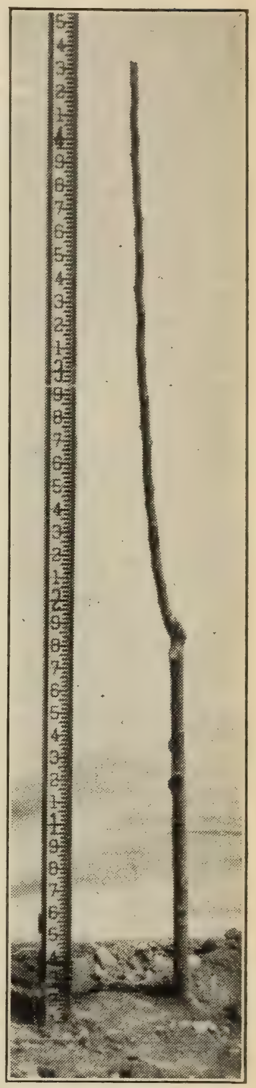


Fig. 78. This apple tree has been headed high enough so that well-spaced scaffold limbs can be selected by the debudding method soon after growth starts.

The principle of dwarfing certain limbs by heavier cutting is often employed in training young trees. If two branches of practically equal size are so arranged as to form a bad crotch, which eventually might split if both were allowed to grow equally, one limb, by heavy pruning, can be dwarfed and made a side branch of the other (Fig. 79). In this way a much stronger framework can be built. Likewise, if it is desired merely to suppress a branch for a few years before removing it, this can be done by pruning it back more severely. A limb on a young tree can also be dwarfed

(*Cornell Exp. Station*)

FIG. 79. Unequal cutting corrects a weak crotch. At the left is a crotch which had two branches of equal size and length. One branch has been cut heavily in order to dwarf it in relation to the other. At the right, the results of pruning one branch heavily can be seen. One branch was headed back heavily three years ago as indicated by the arrow. Note that it has now become a side branch of the other and that there is little danger from splitting with a load of fruit.

or checked in comparison to others by simply thining out some of its lateral branches, thus reducing the leaf area rather severely.

(*b*) *A Low-Headed Tree Is Advisable.* The region on the trunk of the tree where most of the main framework branches start is spoken of as the "head" of the tree. It is well to remember that the "head" of a tree does not grow higher from the ground as the tree gets older. In fact, as the main limbs increase in diameter, the lower surfaces of the limbs become somewhat closer to the ground—the center of the branch remains at the original distance and the upper part of the branch is somewhat farther away. Thus limbs 5 feet from the ground on old trees were at the same height, if measured from the center of the branches, when the trees were young.

A few years ago trees were often headed high—5 or 6 feet from the ground. It was felt that the ground under such trees could be cultivated more thoroughly and more easily. In recent years, however, trees are being headed much lower—20 to 36 inches. Such trees attain large size earlier than high-headed trees which must be pruned heavily during the first two or three years in order to produce a high head. All lower limbs in high-headed trees have to be removed from the central stem until a height of 5 or 6 feet is reached, and this is a dwarfing process. It is evident also that lower-headed trees can be pruned and sprayed, and the fruit thinned and picked, much more easily and cheaply. Cultivating tools with extension sides now permit the orchardist to work the ground satisfactorily and conveniently under the branches. Low-headed trees are subjected to less whipping about and bending by the winds.

(*c*) *The "Modified Leader" Form of Tree Is Recommended.* Apple trees are usually trained to some general form or shape, such as open head or vase form, center leader, or modified center leader. The form to which a tree is trained is not so important, however, as the question of how much and when to prune. Trees pruned properly by any of the methods will grow and fruit well.

In the **open-head** form, the central shoot or leader is removed after one year's growth, if one-year-old trees are used, or at planting time with two-year trees, and three to five limbs, spaced as far apart as possible on the trunk, are left to form the head of the tree (Fig. 80*a*). Advocates of this method claim that it is superior because it allows more sunlight to enter the tree and because the tree does not become so tall as trees trained by the center-leader method. As a matter of fact, the tops and centers of open-headed trees will become quite thick if considerable pruning is not done. The main

FIG. 80. (*a*) Four-year-old Williams apple tree pruned by the open-head system. There has been practically no heading back. (*b*) A tree of the same variety and age in the same orchard but pruned by the two-story center leader system. No heading back has been practiced in this tree either. This tree will probably make a stronger one than the tree shown in (*a*).

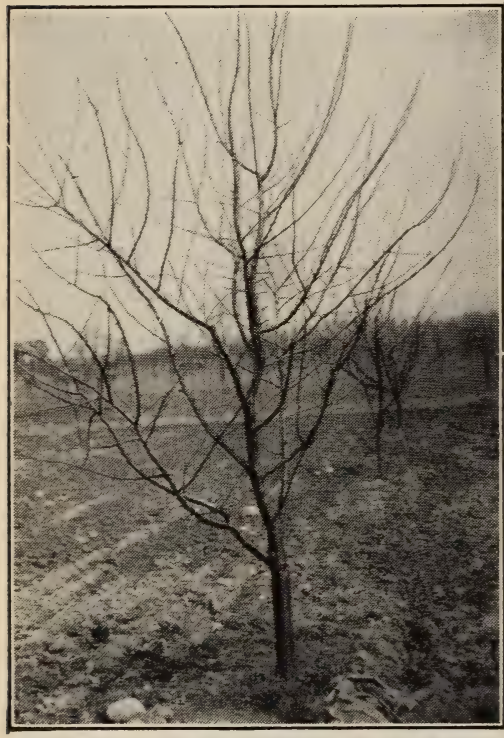
disadvantage of this method, however, is the fact that all the main framework limbs, which are usually equal in size, commonly grow out very close to one another on the trunk. Weak crotches, which tend to split when heavy crops are borne, often result.

When the **center-leader** form of tree is used, the center stem is not removed. Each year additional side branches are trained from the center stem, which is always pruned less

(*Mich. State College*)

Fig. 81. An apple tree that has grown two years according to the modified leader system, before and after pruning. Note that, in addition to removal of some shoots, the upper right fork has been cut back to make the left fork dominant and thus avoid a bad crotch.

severely than the other branches (Fig. 80*b*). These branches, being better spaced and coming out at a wider angle than those of the open-headed tree, are less liable to split out when crops are borne. Such trees, however, tend to become quite thick and to continue upward growth. Unless special attention is given to these matters, the trees become very high and the fruit poor in color.



(*Mich. State College*)

FIG. 82. There is an excellent distribution of branches in this six-year-old Delicious tree.

The **modified-leader** form affords the advantages of the other two systems, with few if any of their disadvantages. In this system, the center or top limb is left for 3 or 4 years before it is headed to an outward growing branch. Thus a leader 4 or 5 feet in length is the result. Plenty of well-spaced limbs coming out at wide angles from the trunk can be selected to form the main framework of the tree (Fig. 81). This results generally in a much stronger tree than the open-headed type (Fig. 82).

Some growers who train their trees according to the modified-leader system remove all undesirable shoots from one-year-old trees a short time after growth starts. This method is explained later under peach pruning.

It should always be remembered that each variety of apples has a characteristic growth, and that as a result, certain varieties may be more easily trained to a certain form than others. In fact it will not be wise to attempt to make all varieties conform to one ideal in shape. One can work toward the ideal in a general way with all varieties, but to be exacting might cause so much pruning as to be uneconomical.

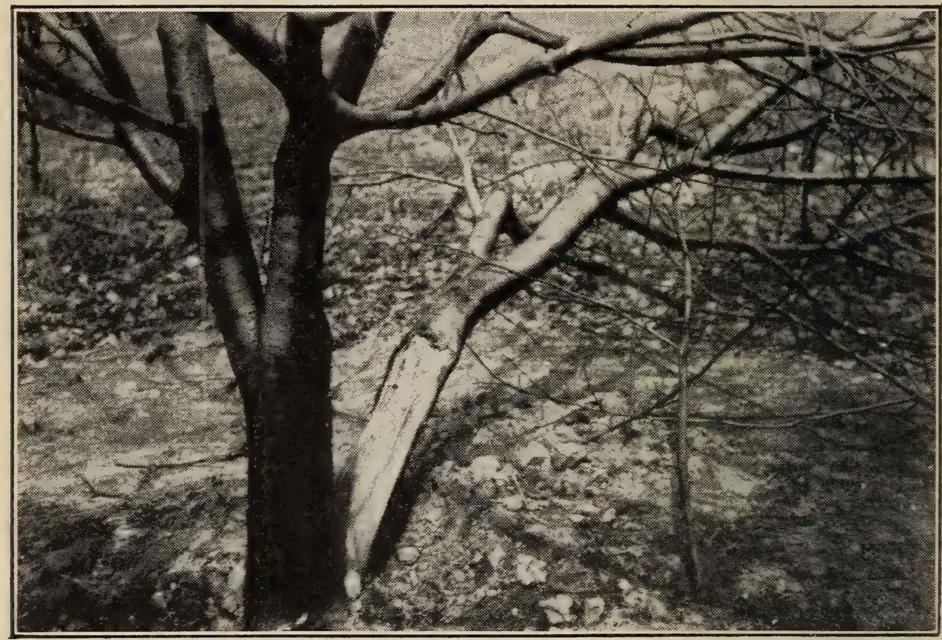
Very often corrective pruning can improve the shape of the tree (Fig. 81).

(*d*) *In Training and Pruning Young Trees, Do as Little Cutting as Possible Consistent with Building a Strong, Well-Formed Tree.* It is apparent from the preceding paragraphs that any pruning given the young tree will cause dwarfing

FIG. 83. (*a*) Lightly pruned five-year-old Stayman Winesap orchard in West Virginia bearing a crop of fruit. (*b*) A six-year-old McIntosh tree which has been pruned heavily each year since planting. Such pruning dwarfs the tree, reduces fruit spur formation, and seriously delays bearing.

and will delay and decrease production (Fig. 83). However, a certain amount of pruning is necessary in order to insure a strong and well-formed tree, even if some dwarfing does occur. Thus in forming the main head of the tree, branches which will always be undesirable should be removed at once. Limbs coming out below the head should be removed. Two limbs should not be allowed to parallel each other closely, since each will partly shade the other. The least desirable should be removed, at least before too much crowding occurs. The main framework branches should be well spaced (from 8 to 10 inches or more apart) about the trunk, and those forming wide angles with the trunk should be selected (Fig. 84).

Five to seven branches may be left to form the head of the tree if the modified-center-leader system is used. The framework branches may be spaced over a distance of 4 to 5 feet.



(*Mich. State College*)

FIG. 84. The result of permitting three branches of equal size to arise from a single point.

Often only two or three of these and the center leader are selected after the first year's growth. The remainder are secured in the course of the next two or three years. As previously indicated, the leader can be directed out into a side branch at any time by cutting back to an outward-growing branch.

The main framework branches should be headed back during the first two or three years, if they are making long growths. No definite amounts of heading back, such as 10 per cent or 20 per cent, can be recommended. If the branches are making a length growth of more than 2 feet, it will probably pay to head back to this length. This will insure the formation of new secondary branches low enough to prevent the tree from becoming too "willowy" or "leggy." If the limbs are headed too severely, serious crowding of the secondary branches will result.

Secondary branches which are selected for continuing the framework of the tree each year should not be shortened back equally, if heading back is practiced. When such branches originate close together, bad crotches will occur as previously described if one is not dwarfed by reducing the leaf area through heavier cutting.

As a whole, *thinning out lightly* should be practiced in preference to heading back, unless the shoots are unusually vigorous. It should be remembered, however, that the more severely a tree is cut back, the longer will be the growths of the resulting shoots, which may mean heavier pruning again the next year.

It is not advisable to thin out non-bearing or young trees severely. Although the trees may look better to some people if all growths on the insides of the main limbs are removed, such pruning will remove large number of leaves which, unless under badly shaded conditions, would contribute greatly to the growth and fruiting of the tree. It should be remembered that each branch with its leaves adds to the tree's food probably much more than it uses. As a result, the longer such branches can be left, suppressing them with pruning if necessary, before finally removing them, the sooner the tree will attain large size and profitable bearing (Fig. 85).

Pruning Young and Old Bearing Apple Trees. This subject has already been treated on pages 226 and 229.

Rejuvenation Pruning of Apple Trees. It will often pay to attempt to rejuvenate old orchards even though they may have been neglected for several years, if the orchard is located on good soil with good air and soil drainage, with few missing trees, with desirable varieties, and if the trees are not mere skeletons from heartwood decay.

In addition to spraying, fertilization, and proper soil

(*Mich. State College*)

Fig. 85. The type of young bearing apple tree for which the grower should strive.

management, pruning is an important factor in the rejuvenation of such orchards. As a rule, the trees are quite tall, with very little fruiting wood except at the ends of long, polelike branches. Many dead limbs and stubs are in evidence. If the trees are too close together, part of them, usually alternate trees, should be removed. One of the first things to do in pruning is to remove all dead limbs. Cut them off close to the limbs from which they are growing, or close to the trunk if they are attached directly to it. If the main scaffold limbs are too numerous remove some of them. The tops of the trees will usually need lowering, if vigorous fruiting wood is to be produced where it can be pruned and the crops thinned, sprayed, and picked efficiently. In such cases head back to side branches. It is not necessary or desirable to head back more than 5 to 10 feet the first season.

All branches left should be thoroughly thinned out by making many small cuts to reduce competition and to admit sunlight to all parts.

As a result of such severe pruning, water sprouts or "suckers" will probably grow in considerable numbers. Where limbs are needed, the most vigorous of these sprouts can be saved, and shortened back the following year. It is surprising how quickly they will develop, complete the symmetry of the tree, and bear fruit.

In removing large limbs, it is advisable first to saw up from the under side of such limbs. They can then be sawed through from above so that splitting and tearing of the wood and bark will not result when the limbs fall.

With fertilization, pruning, spraying, and proper soil management, such orchards can often be completely reclaimed. Future pruning should be as indicated for bearing trees.

Protecting Pruning Wounds. It seems unnecessary to paint wounds smaller than 2 inches in diameter, as they heal quickly.

When large limbs are removed, the wound should be protected from disease organisms, sun, wind, and rain by covering with some suitable material. Coal-tar preparations, asphaltum mixtures, grafting wax, zinc paint, water glass, white lead, and various other materials are used. All these materials, except grafting wax and possibly the water glass (sodium silicate), injure the cambium to some extent. As a result, delay painting the wounds for a year until the cambium is protected by bark, unless wood-decaying organisms are serious. White lead is a satisfactory covering, but many others are being used successfully.

The Pear

The pear is so similar in fruiting habit to the apple that many of the recommendations given in reference to pruning the apple can be adopted.

(*a*) *The Pear Is Trained Either by the Pyramidal, Open, Modified-Leader, or Natural Form.* In many sections the pyramidal or center-leader form of tree is used. The open-headed or vase form seems to have preference in the large pear-growing regions of the West, since it is easier to control pear blight in trees pruned by this method. Compared to the pyramidal form the trees pruned to the open-headed form have fewer main branches, are not quite so thick as a result, and consequently blight can be seen and controlled more easily. It is also easier to keep blight from becoming established in the main limbs and trunk when the center leader is removed. In the more open trees any blighted spurs on the lower limbs can be seen and removed immediately, and thus infection at these places can be checked.

The modified-leader type of tree combines many of the advantages of the other two systems and may well be used in many sections. Trees allowed to assume a natural form, no definite effort being made to force them into any one system, often are very satisfactory.

(*b*) *Young, Non-Bearing Trees Should Be Pruned Lightly.* What has been said relative to pruning young apple trees applies, for the most part, to the pruning of young pear trees.

If the main branches make too long a growth (more than 30 to 36 inches) during the season, they should be shortened back, since pear branches are inclined to break off (generally above the crotch) more than apples. Some growers prune the young trees quite heavily each year in an effort to prevent this breaking of limbs, but such trees become dwarfed and are late in coming into bearing. Many growers prune very little, however, in order to get a tree large enough to bear commercial crops as soon as possible. In such cases several crops might be secured before a really serious blight year is encountered.

Figure 86 shows a three-year-old pear tree before and after pruning.

With pear varieties that are very upright growers, it will pay to cut back to outside buds or branches when heading is practiced, in order to encourage a more spreading shape.

(c) *Bearing Trees Respond Well to a Heavier Type of Pruning.* The "set" of fruit, especially with some varieties as Bartlett and Anjou, is often increased considerably by practicing heavier pruning after the trees have come into commercial bearing. Size of fruit, likewise, is often benefited. It is well to remove the fruit spurs on the lower parts of the limbs near the trunk, if they have not previously been removed, in order to prevent the entrance of pear blight at these points. A certain amount of thinning out and some heading back to outward growing laterals will usually be beneficial.

With old and high pear trees making a very short growth, and with numerous weak fruit spurs, a thorough thinning out of many of the small branches and a moderate heading back of the main limbs are desirable. The spurs on such old trees normally make only a weak growth each year, blossom irregularly, and often set very little fruit. A thorough pruning, by eliminating many of the spurs and buds while the roots remain the same, results in more water and nutrients being available to the remaining buds. As a result, terminal growth is greater, new spurs are formed, the old spurs make a better growth, the leaves about each spur become larger and greener, fruit buds are formed, and more fruit is produced. No doubt better cultural and fertilizer practices will also be beneficial, but with these old trees great benefits are derived from a thorough pruning.

(*Mich. State College*)

Fig. 86. A three-year-old pear tree before and after pruning. A lateral threatening the supremacy of the leader has been checked, and an attempt has been made to spread the tree by cutting to outward-growing laterals.

The Peach

The fruit of the peach is borne on the previous season's growth, or one-year wood. Usually this bearing wood consists of terminal and lateral shoots which are produced over the outer surface of the tree, but occasionally these shoots or twigs are quite short, especially if the trees lack vigor. Such growths are often called spurs, although they are not the same as the spurs of the apple and pear.

The sooner a tree of large proportions can be grown, the sooner it will come into profitable bearing. It can thus be seen that the less pruning that can be done consistent with forming a strong well-shaped tree, the better.

(*a*) *At Transplanting Time the Young Trees Should Be Headed Back.* Well-matured trees of medium to large size are desirable for planting. The usual practice in most sections is to cut back these "whips," leaving them from 18 to 22 inches high. This allows for a low-headed tree and still leaves room for working the soil and combating borers. If no buds or limbs are present below this height, then the trees should be headed higher. If the buds below this region have grown out into weak branches in the nursery, these branches should be cut back to stubs of one bud. New limbs will grow either from dormant buds at the base of these stubs or from the buds left on the stubs. If the tree as it comes from the nursery has numerous strong, well-matured, and well-spaced branches—which is not usual—these can be thinned out, three or four being left and shortened back moderately.

A promising method of pruning after transplanting is indicated later in this section.

(*b*) *After the First Season's Growth the Main Framework Branches Should Be Selected.* During the first season's growth, several buds will grow out into branches. The following spring three or four of these branches spaced as far apart as possible and spirally about the trunk should be selected to form the head of the tree. The remaining branches should be removed. Three limbs are sufficient to make an excellent tree, if nothing happens to one of them. If, however, one of these limbs is broken out during cultivation by careless labor, as often happens in some of the large orchards, the size of the tree becomes seriously decreased for a year or two until new branches can fill in the space. In many trees at least four, or possibly five, scaffold limbs are desirable.

(*Md. Exp. Sta.*)

Fig. 87. (*a*) Two-year-old peach tree after being pruned lightly. Main limbs were headed to outward-growing branches, but laterals were not clipped back. Shoots in center of tree were not removed. This tree will reach large size quickly and bear early and large crops. (*b*) Two-year-old peach tree in same orchard as (*a*). This tree was pruned heavily. Such pruning dwarfs the tree and delays bearing.

These scaffold limbs should usually be headed back, the amount depending upon the growth that they have made. If the limbs selected are not more than 2 feet in length, it will not be desirable to head them at all. If the scaffold limbs are 3 feet in length, it will probably pay to head back 6 or 8 inches to the first group of laterals, which usually occur on such limbs. This will cause the formation of the secondary scaffold branches far enough out from the trunk to secure a large tree quickly without making it too "leggy" or "willowy." (In regions where tip injury from the Oriental peach moth is severe during the middle of the growing season, no heading back will be necessary.)

(*c*) *After the Second Year's Growth Select Three or Four Strong Laterals from Each of the Main Limbs Left the Year Before to Continue the Framework of the Tree.* The remaining shoots should be thinned out moderately, and those left should be headed back more severely than these framework branches. This unequal cutting, owing to the resultant decreased leaf area, will dwarf such branches in comparison to those left to form the main framework. It is neither necessary nor wise to clip back all the small laterals on these main branches, but they should be moderately thinned out (Fig. 87).

(*d*) *Continue Building the Framework Following the Third Year's Growth.* About three branches should again be selected on each of the main branches left the year before to continue the framework of the tree. These should be headed back lightly to outward-growing branches and thinned out moderately. The shoots in the center of the tree should not be removed at this age, because a large percentage of the first crop is borne on these shoots.

This method of light pruning, together with early and thorough cultivation, and the addition of larger amounts of available nitrogen fertilizers where needed, should produce a tree capable of bearing a good commercial crop during the fourth year.

(*e*) *A Promising Method of Training and Pruning Finding Favor in Some Sections Is Illustrated in Fig.* 88. This has given a tree of good size, with branches better spaced than in trees headed according to the usual practice.

(*f*) *Bearing Trees Respond Better to a Somewhat Heavier Type of Pruning Than That Practiced with Young Trees.* Even with these older trees pruning may easily be too severe for the largest and best fruit production. Experiments and observations show that it is not a wise practice to shear off

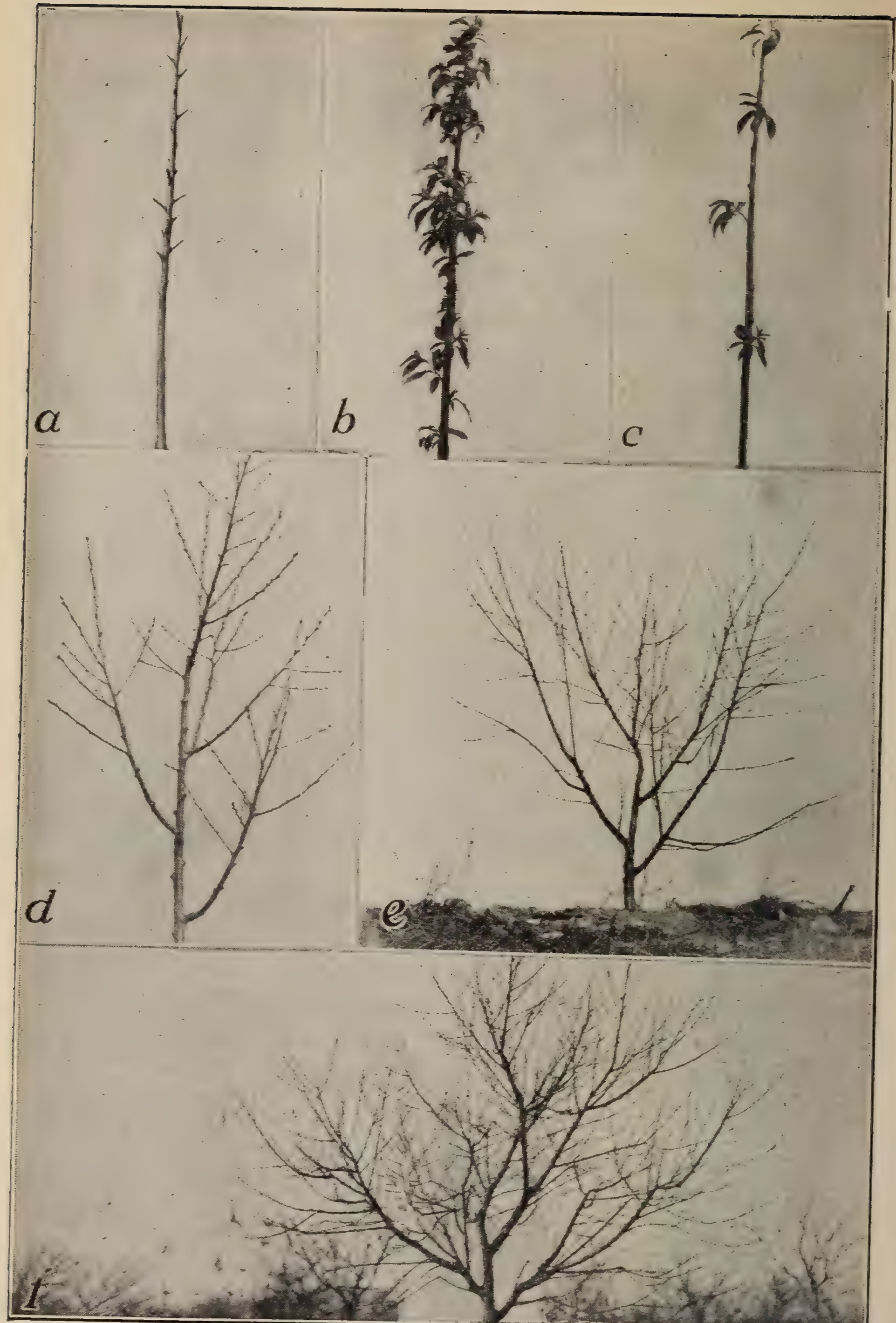


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Fig. 88. Peach trees pruned according to new system. (a) At planting time, the tree was cut off at about 40 in. and side branches were cut to stubs. (b) After two weeks of growth. (c) Four well-spaced shoots were selected. (d) After one year's growth, note strong well-spaced branches, requiring little pruning. (e) After two year's growth. (f) After three years. Such a tree requires little pruning after the first year.

uniformly the tops of bearing trees each year. In some sections every shoot is headed back heavily with very little thinning out, and the tops of the trees resemble a well-clipped privet hedge. As a result of this practice, not only are tree size and total yield reduced but also the fruit produced is generally of poor color.

The shoots on heavily pruned trees also grow later in the season and on account of poorer maturity are more subject to winter injury in regions of low temperature.

(*Md. Exp. Sta.*)

Fig. 89. Four-year-old peach tree before (*b*) and after (*a*) receiving a light pruning. This tree has always been pruned lightly. Note that a light thinning out and a light heading back of the main branches has been given. This tree has a much larger bearing surface and is capable of producing a much larger crop than a tree of the same age heavily pruned.

The branches of bearing trees should be headed back moderately to outward-growing branches (Fig. 89). The centers of the trees should be kept reasonably open in order that the fruit will color well and in order to keep up the growth of new shoots on the main branches (Fig. 90).

After four or five heavy crops have been produced, it is well to head back more severely than usual for one year and especially to cut out the higher limbs, which are growing toward the centers of the trees. The tops of the main framework branches may be headed back into two-year wood, leaving the side branches and laterals to bear the crop. This may reduce the crop somewhat for the one year, but will cause new growth to be forced out lower down on the trees, especially on the inside of the main limbs. Thus new limbs can gradually be developed and the tree lowered without the loss of a crop. After moderate pruning again for four or five years, the trees may again be rebuilt gradually by this method.

Fig. 90. The branches of lightly pruned peach trees bend down or "open up" with their crop of fruit. Sunlight reaches all parts of the tree, and the fruit is usually well colored. Practically all the fruit can be picked from the ground.

(g) *When Peach Trees Are Pruned Lightly Each Year, Other Orchard Operations Must Be Modified.* Lightly pruned trees of course become much wider, and require more space in the orchard, than heavily pruned trees. As a result many growers are now planting their trees 22 by 22 feet or 24 by 24 feet instead of the old distance of 18 by 18 feet. With the advent of paradichlorobenzene for borers and the general benefit secured from nitrogen applications, together with pruning rejuvenation practices, many growers are now planting peaches in solid blocks with the idea of a comparatively long-time investment. Although the number of trees per acre is less because of the greater planting distances, the total yield per acre, as a result of the larger trees, is higher and the color of fruit is usually much improved. The initial investment is less for trees, and pruning costs are likewise decreased.

It is reasonable to suppose that, if enough more wood and buds are left on a tree at least to double its yield, more moisture and fertilizers will be needed. Thus the grower who has been pruning severely, fertilizing little, cultivating moderately well, and securing an average yield of 1½ bushels per tree will find himself in trouble if he decides to prune lightly and does not adjust his other practices in proportion. If nitrates have paid under the heavy pruning system, larger quantities will be required if lighter pruning is practiced, the fruit should be thinned more, early and thorough cultivation should be given, and those cover crops which will make the most organic matter under the local conditions should be used. In light soils, especially, large amounts of organic matter should be turned under, not only from a general fertility standpoint but also as an aid in increasing the water-holding capacity of the soil.

Note that in all recommendations given it has been pointed out that bearing trees should be thinned out moderately, and that the limbs which are to continue the framework of the tree should receive a light to moderate heading back.

(*h*) *Pruning Is Very Important in Restoring Old Orchards to Fruitfulness.* Many old peach orchards which have gradually become unproductive, with long, bare limbs extending 15 to 20 feet high, can be rejuvenated and made productive by proper methods of spraying, pruning, fertilization, borer control, and soil management.

Many methods of rebuilding such trees have been advocated. Under most conditions it is best to prune the whole tree moderately the first year (Fig. 91). Trees headed back into three- or four-year wood, leaving the main branches 6 to 8 feet long, with stubs of the lateral branches attached, generally produce shoots of moderate vigor, which form sufficient fruit buds for a fair crop the next year. Although the trees are lowered to some extent, their bearing areas (height and width) are not reduced so severely as in the dehorned trees. After one year's growth the bearing surface should nearly equal that of normal, healthy, bearing trees. Owing to the absence

FIG. 91. Fourteen-year-old peach tree pruned moderately heavy. Note that all main leaders have been headed back to outward-growing branches but that the remaining shoots have not been clipped back. Such a type of pruning on old trees results in a good supply of new bearing wood each year.

of dense growth, the fruit is also of normal color on such trees.

Experiments at the Maryland Experiment Station have shown that dehorned trees yielded 1¼ pecks per tree after the first year's growth following the treatment, 1½ pecks the second year, 9¾ pecks the third year, and 4 pecks the fourth year following the pruning. Moderately pruned trees in the same orchard during the same years yielded 4 pecks per tree after the first year's growth, 8 pecks the second year, 18 pecks the third year, and 14 pecks the fourth year. Thus the dehorned trees averaged a little less than 1 bushel per tree per year for the four years following the pruning, whereas the moderately heavily pruned trees averaged 2¾ bushels per tree per year during the same period.

(*i*) *Proper Pruning Is Especially Important after the Loss of a Fruit Crop from Frosts or Freezes.* When frosts have destroyed the blossoms or the fruit buds have been killed on young trees four to six years old by low winter temperatures, many growers prune such trees very heavily. The theory is that since the crop is lost the tree can be materially lowered and a new top produced. It seems unwise, however, to prune such trees back into three- or four-year-old wood after such catastrophes. Since the crop has been lost, most trees, even without nitrogen applications, will make an excellent growth, unless severe wood killing has resulted. Cutting back into three- or four-year-old wood will simply decrease the size of the tree for the next year's crop, and may cause such a rank, dense growth that comparatively few fruit buds will be formed. Sometimes it takes from two to three years for such trees to regain their original size so that good yields per tree may be secured. Usually a light thinning and heading back is all that is needed.

When the wood of two- or three-year-old trees is badly winter-killed to the pith, it will probably pay to prune back the main branches to stubs in order to rebuild a main framework of healthy, sound branches so that future breakage will be avoided.

Older bearing trees should be pruned more heavily than young bearing trees after frost or winter injury. An opportunity is afforded for lowering to some extent the height of such trees and rebuilding with new wood. However, even with these trees it is easy to do too much pruning. It seems better even with trees frozen severely to prune moderately.

The Cherry

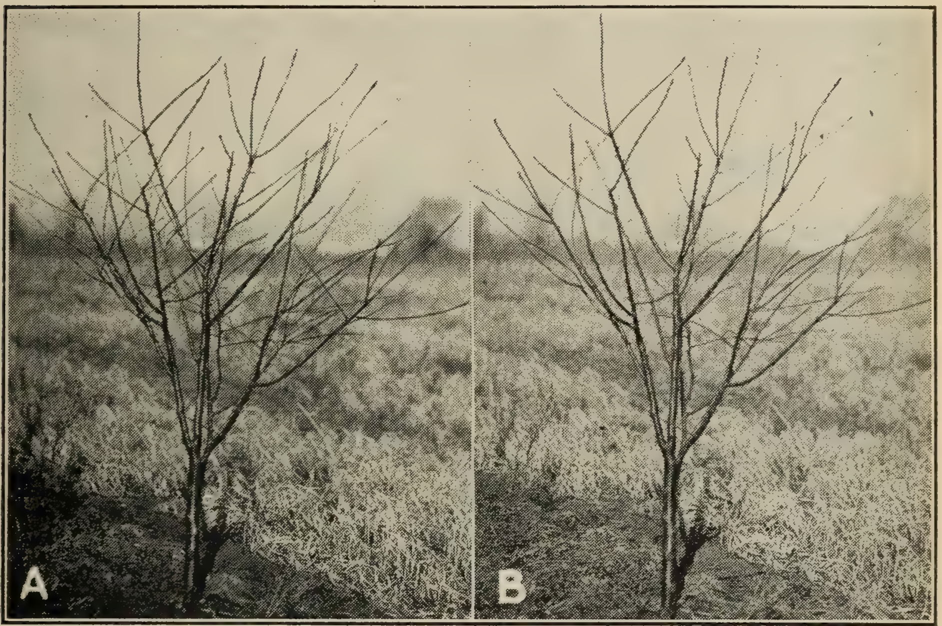
Sweet and sour cherries normally make a somewhat different type of growth and hence require different pruning treatments.

(*a*) *Prune Young Sweet Cherry Trees Just Enough to Form a Desirable Framework.* Although sweet cherries are trained by several different systems, the open-head or modified-leader type of tree seems to be most satisfactory under most conditions. Many varieties of sweet cherries tend to produce upright branches and thus tall trees if the center leader is used.

At planting time, if two-year-old trees are used, four or five main branches should be selected for the main framework, and all others, including the central leader, removed if the open-head system is to be employed. These branches should be shortened, leaving them 20 to 24 inches long. If the modified leader tree is desired, the center leader should not be removed, but should be shortened somewhat in proportion to but not so much as the main branches. Three or four additional framework branches are then selected during the next two or three years, after which the leader is suppressed by cutting it back to an outward-growing branch. If one year-old whips are planted, these should be cut back to 24 to 30 inches, with similar treatment as the head develops.

Pruning during the first three or four years should consist of light thinning out, the removal of crossing and interfering limbs, and light heading back to outside buds or branches in order to encourage a more spreading habit. Most of the crop is borne laterally on spurs in the sweet cherry. The tree branches very little as it gets older, and it is consequently unnecessary to thin out very much to admit light and air. As the trees increase in age, it may be desirable to do some cutting back of the upper limbs to outward-growing branches in order to cause additional branching, new spur development and an invigoration of the old spurs.

(*b*) *The Modified Leader System Is Desirable for Training Sour Cherries.* The amount to cut back two-year-old sour cherry trees at planting time is a debatable question. In some regions, especially in some southern sections, many trees die if headed back at transplanting time. However, in parts of Wisconsin, where a large acreage of sour cherries is grown,



(*Mich. State College*)

Fig. 92. A two-year-old Montmorency cherry tree before pruning (*A*), and after pruning (*B*); only a few superfluous in-growing shoots have been removed.

the trees do better if the scaffold limbs selected are headed back to about 18 inches when the trees are set.

When the modified-leader system of training is used, four or five of the strongest and best-placed branches should be selected, the leader should be left, and all other branches should be removed. The lowest branch is generally 20 to 24 inches from the ground. During the next two or three years four or five additional framework branches should be selected and the leader then cut back to an outward-growing branch.

Trees pruned by this method are usually spreading, are easy to pick, and develop good spur systems (Figs. 92 and 93). Crossing limbs should be removed, and if the laterals grow more than about 24 inches in length, these should be lightly tipped back during the first three or four years to cause branching and to prevent legginess.

Fig. 93. An Early Richmond sour cherry tree in Wisconsin pruned according to the modified center leader system.

Contrary to popular belief, recent experiments in Wisconsin show that bearing sour cherry trees respond well to moderately heavy pruning. After six or seven years' growth, care should be taken to thin the tops, in order to keep the inner spurs and lower fruiting wood healthy and productive.

Branches growing toward the center of the tree should be removed and the main limbs should be headed back lightly to outward-growing branches. This type of pruning, together with fertilization and good cultural practices, will cause a stronger growth throughout the whole tree, the old spurs will be invigorated, more blossoms will set, and larger numbers of new spurs will be formed.

It will be recalled from Chapter IV, "The Growth of the Tree and the Forming of Fruit Buds," that fruit buds of the sour cherry are producing laterally on one-year shoots and on spurs. Short terminal and lateral growths 5 to 8 inches in length usually form fruit buds at each node, and as a result no leaf buds are available for developing fruit spurs. When longer shoots (10 to 18 inches in length) are produced, fewer lateral fruit buds and more spurs are formed. A tree with numerous spurs has a much larger fruit-producing system, and in the Northern regions buds on spurs seem to be more resistant to winter freezing than those on shoots. Under such conditions it can readily be seen why a heavier type of pruning for increasing terminal and lateral growth, in order to develop a large spur system, would be desirable.

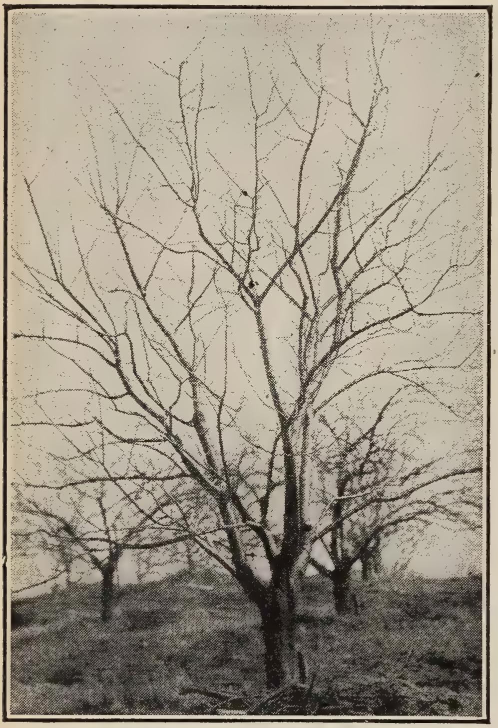
The Plum

Although there are several different species of plums, the chief species grown are the Japanese plums (*Prunus salicina*), the European plums and prunes (*Prunus domestica*), and the Damsons (*Prunus insititia*). The Japanese varieties usually make a more spreading growth than the others, and come into bearing earlier.

The Japanese varieties usually bear more fruit laterally on one-year wood, like the peach, than do the other kinds of plums. Considerable fruit of all plums is borne on spurs. These spurs are often quite short, causing the lateral buds to appear in clusters in the Japanese plums.

(*a*) *Young Trees Should Be Pruned Rather Lightly.* Plum trees need very little pruning while young. The Japanese plums are generally pruned by the open-head system, whereas the European varieties are more often trained with the center leader. However, the modified-leader system is satisfactory for all plums and should be used more widely.

The Japanese varieties should be pruned a little more heavily than the others in order to obtain trees of good shape and to cause a good growth of shoots, upon which new spurs and considerable fruit are borne the following year. This heavier cutting is especially important with the Burbank, which is a low-spreading grower. Thinning out of slender branches seems especially desirable with this variety. Other varieties which make a narrow, upright growth, such as Wickson, should be headed to outward-growing branches in order to secure a more spreading tree.



(*Cornell Exp. Station*)

Fig. 94. Bearing European or Domestica plum tree after pruning. Note that thinning out and light heading back have been practiced.

Most of the European varieties develop into trees of good shape even if very little pruning is done. It is well to keep the centers of the trees thinned sufficiently to admit sunlight and thus maintain a healthy spur system on the main limbs.

(*b*) *Bearing Trees Require Heavier Pruning.* The Japanese plums bear such heavy crops while young that they soon need a heavier type of pruning in order to stimulate new shoot growth, keep the spurs in a healthy condition, and produce fruit of good size. Owing to the characteristic growth of the trees, it is usually necessary to do some heading back of the terminals and laterals in addition to cutting back the main limbs to outward growing branches.

The European plums should be thinned out by removing some of the small branches and by heading back the main limbs lightly to outward-growing branches (Fig. 94). After these trees have become quite old and have borne many crops, terminal growth is usually short and spur growth very weak unless heavy pruning, fertilization, and good soil management are practiced. With such trees a thorough thinning of the small, thickly spurred branches should be made and the lower limbs, as well as the tops of the main limbs, should be thinned out and shortened back to healthy lateral branches (Figs. 95 and 96). This heavier pruning will admit more light, invigorate the old spurs, cause a better set of fruit, and increase terminal growth so that new spurs will be formed.

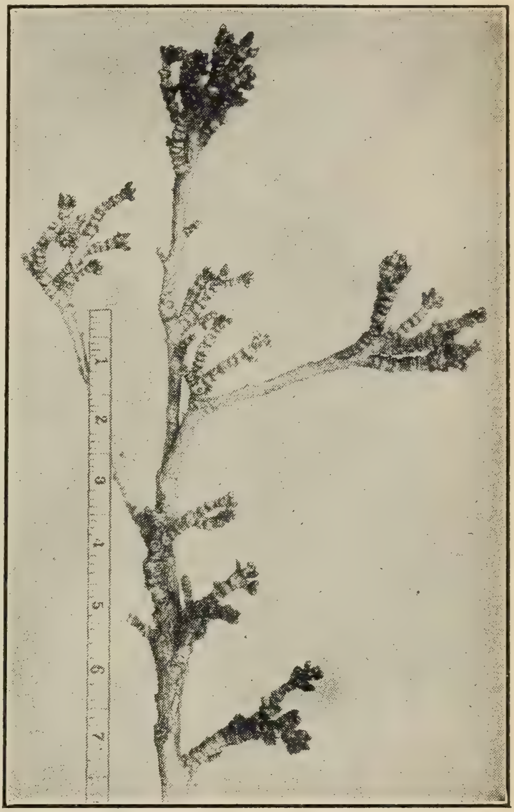


Fig. 95. The ends of a lateral branch on an old plum tree. The spurs are very weak; very little terminal or spur growth is being made. Increased pruning, cultivation and fertilization of the soil would promote growth and fruit production.

The Apricot

The fruit-bearing habit of the apricot is in general quite similar to that of Japanese plums. Much of the fruit is borne on short spurs along the branches, but a portion of the crop is also produced laterally on the one-year-old shoots.

The pruning of the apricot should be much the same as that described for the Japanese plum. The fruit spurs of the

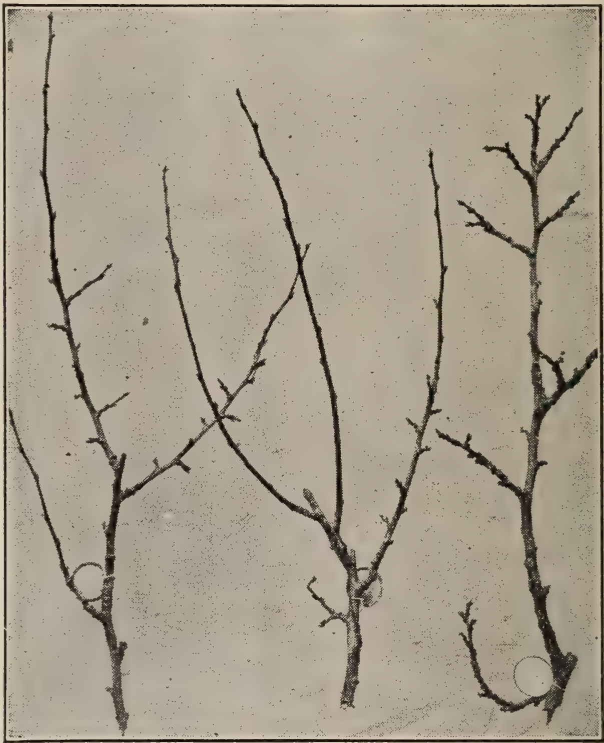


Fig. 96. This illustrates the results of pruning an old prune tree. At right, an unpruned branch; at left, a branch pruned two years before picture was taken; in center, branch pruned one year before picture was taken. Pruning has resulted in new growth of wood and the formation of vigorous spurs.

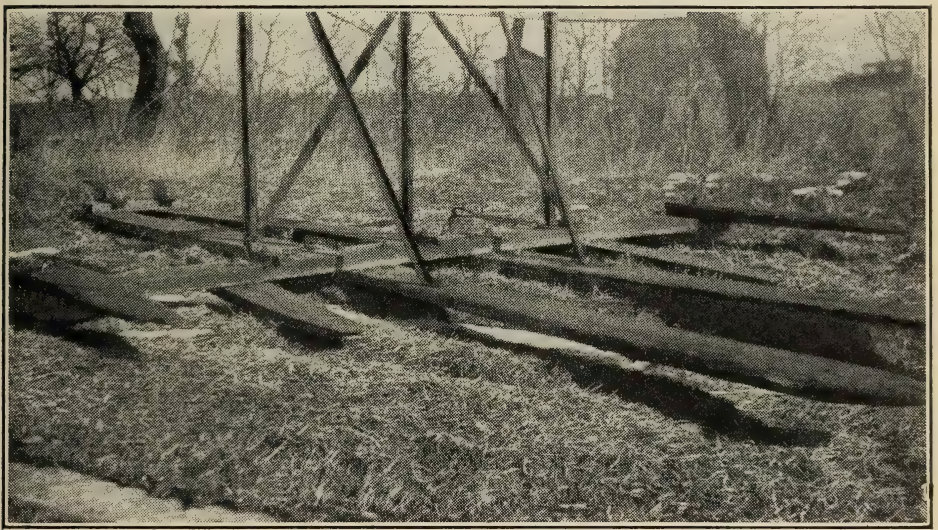
apricot are shorter-lived, however, than those of plums, and as a result a slightly heavier pruning should be practiced with the apricot in order to keep the spur-system renewed.

As the trees become old and especially after several heavy crops have been produced, it is desirable to increase the amount of pruning in order to stimulate growth and increase the size of fruit.

The Quince

Practically no experimental evidence relative to the best method of pruning the quince is available.

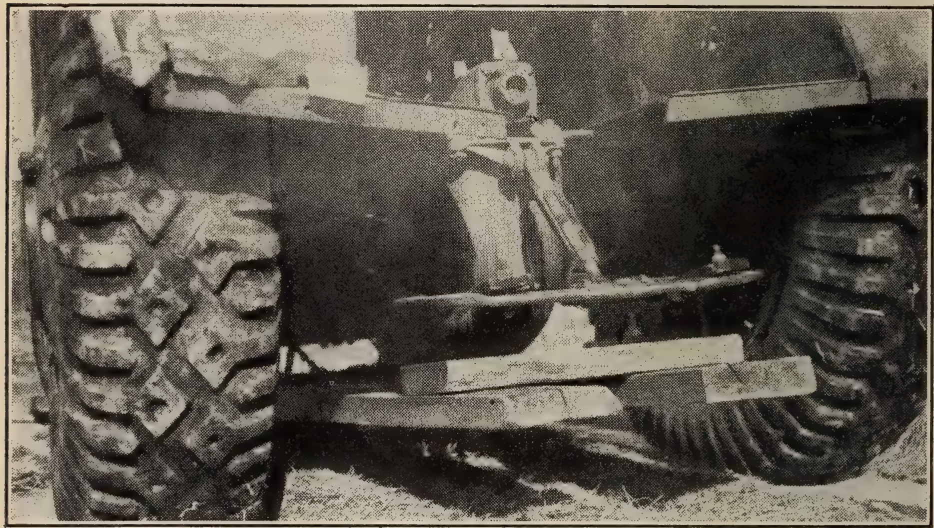
In general the trees are trained to a low-spreading head, the centers are kept open, and some heading back of the main limbs is practiced during the first few years.



(*E. W. Mitchell*)

Fig. 97. This illustrates an effective home-made type of brush pusher. The job of gathering and burning brush in a modern orchard is substantial and difficult. This pusher is tractor operated. Take two hickory, ash or oak pieces, 2 inches by 6 inches, about 18 feet long; lay them under the tractor and fasten to drawbar as shown in Fig. 98. Flare the pieces outward in front of the tractor, but allow clearance when tractor wheels are cramped. Bolt chains from two points on the long cross piece to the front axle to permit steering the device, and bolt on short pieces as shown to make a rigid job. Taper the prongs on top surfaces; erect a strong well-braced guard for the engine radiator. Allow space back of guard for cranking the tractor. The brush packs on firmly and can be pushed directly on to the fire, backing the tractor away. Do not build large fires. Small fires are more convenient and safer.

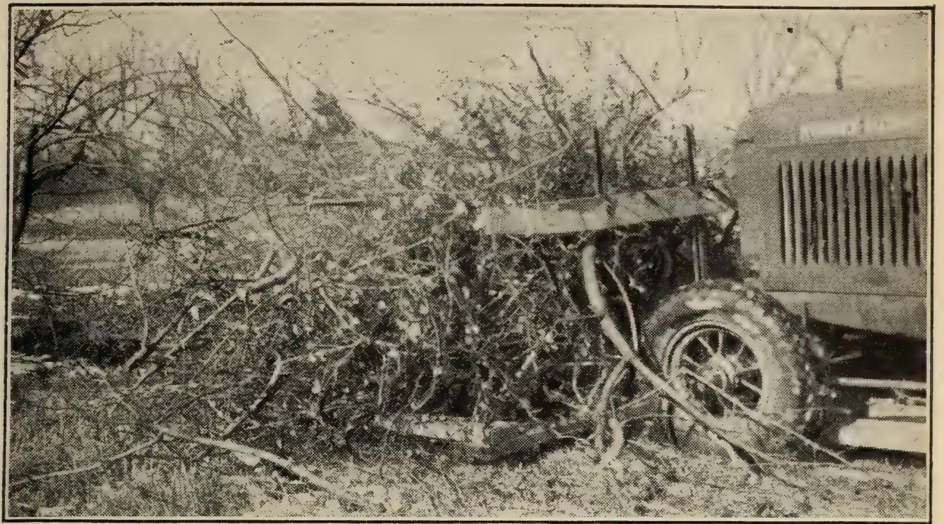
It will be recalled from the chapter on the growth of the tree and the forming of fruit buds that fruit is borne on the ends of small shoots which grow from the terminal or lateral buds formed on the previous season's growth. Although old trees generally bear some fruit annually, even without pruning, this type of fruiting suggests that in addition to thinning out the bearing tree, some heading back to laterals should be practiced so that new growth will be stimulated each year.



(E. W. Mitchell)

Fig. 98. Showing detail of hitch of brush pusher to tractor.

5. Determining Pruning Costs. The cost of pruning is influenced by many factors: age of tree, variety, height and width of tree, kind and amount of previous pruning, and the type of labor. The New York State Experimental Station at Cornell has found that for most varieties the cost of pruning can be reduced by pruning every other year. Its experiments indicate that equally good yields of quality fruit may be obtained by this biennial practice. This means a considerable saving in pruning time. Up to picking time in the Hilton area of New York, from 1928 to 1931, with both sod and cultivated orchards, labor for pruning made up one-half of the total labor cost. It was found that in orchards 30 years old or older,



(*E. W. Mitchell*)

FIG. 99. The brush pusher (Fig. 97) in operation.

TABLE 37

PERCENTAGE OF TREES PRUNED AND NUMBER PRUNED PER DAY, BY AGE, HILTON AREA, 1928 TO 1931*

Age of Trees in 1930	Records†	Total Bearing Trees	Trees Pruned	Trees Pruned in 10 Hours
	Number	*Number*	*Percent*	*Number*
60 or more..........	92	18,048	43	6.2
50 to 59.............	71	11,696	46	4.7
30 to 49.............	106	18,385	48	6.0
20 to 29.............	157	37,040	65	12.8
10 to 19.............	118	25,873	48	12.7
All ages...........	544	111,042	53	9.0

* Adapted from *Relation of Soil and Cultural Practices to the Costs and Returns in Producing Apples, Hilton Area, Monroe County, New York* (unpublished thesis for degree of Ph.D., Cornell University, p. 33, 1934), by C. C. Spence.

† Includes all cost records taken each year.

one man can on the average prune and dispose of the brush from 6 trees in 10 hours. In younger orchards one man can care for twice as many trees. (See Table 37.)

In Berrien County, Michigan, in 1935, on 80 farms, where most of the trees were between the ages of 15 and 30, the total cost of labor for pruning, for trimming, hauling, and burning the brush averaged \$2.66 per acre. One acre required 15.3 man-hours and 3.4 horse-hours. Man labor was paid at the rate of 15 cents per hour and horse labor at 11 cents per hour. Most of these orchards were under partial or complete cultivation.

In 1930 and 1931 in the Piedmont area of Virginia, with trees of bearing age, the average cost per acre was \$4.36 and \$3.02 respectively. (See Table 38.)

TABLE 38

Cost of Pruning and Removing Brush, Piedmont Area, 1930–31

Item	1930		1931	
	Number		*Number*	
Records included	22		17	
Total acres, bearing orchard	1,476.5		1,160.5	
Acres pruned	1,357.5		893.5	
Trees pruned	52,661		36,004	
	Per Acre Pruned	Per Tree Pruned	Per Acre Pruned	Per Tree Pruned
Man labor:	*Number*	*Number*	*Number*	*Number*
Hours	17.0	0.44	14.7	0.36
Dollars	4.12	0.106	2.73	0.068
Horse work:				
Hours	1.9	0.05	2.4	0.06
Dollars	0.24	0.006	0.29	0.007
Total cost, *dollars*	4.36	0.112	3.02	0.075

Peach trees may be pruned much more rapidly than apple trees, both because they are smaller and because the wood is softer, cutting more readily. In the Shenandoah-Cumberland region it was found that trees from 7 to 14 years of age could be given a light but thorough pruning involving thinning and some heading back of main branches in 10¾ to 14.7 minutes per tree. Younger trees require correspondingly less time.

GENERAL INFORMATION

Removal of Trees from the Orchard

It is sometimes necessary to remove part of the trees in orchards that have been planted too closely. Various methods of accomplishing this are employed.

A good method is to fasten a chain around the main branches several feet above their point of union with the trunk. Hitch a team or tractor to the chain about 20 to 25 feet from the tree. As the team pulls, workmen cut off roots on the opposite side with mattocks or axes. Change the direction of the pull and cut off other roots until the tree is loose and leans over so that the remaining roots may be severed. This plan works very well in light soils but has been used successfully with large trees on heavy soils. In the latter case, however, a charge of dynamite under the center of the tree will help to loosen the roots. Large roots remaining in the soil may be removed quickly by attaching the chain to them.

A block and tackle is sometimes employed, but is a slower method.

Some growers cut off the top at the base of the main branches and leave the trunks until they decay. This works quite well with peaches, the wood of which decays quickly.

In soils that are disked rather than plowed, the soil may be dug away from the trunk and the trunk sawed off just below ground level.

COMMUNITY STUDIES

1. Visit several different orchards in the community at pruning time and secure data on the following questions:

(*a*) Age and kind of trees being pruned.
(*b*) Severity of pruning.
(*c*) Are the trees being headed back? If so, why?
(*d*) Are the cuts being properly made?

(*e*) Are desirable pruning tools being used?
(*f*) Do stubs ever heal over?
(*g*) To what form of head are the trees being trained?
(*h*) Determine whether certain branches have been dwarfed by pruning.
(*i*) How many minutes does it take one man to prune a tree, and what is the cost per tree?
(*j*) Does heavy heading back cause more branches and thus a denser tree?
(*k*) Are the large pruning wounds being protected from the weather, insects, and diseases?

2. Notice that some varieties normally grow upright whereas others make a spreading growth. Should an attempt be made by pruning to make all trees assume the same shape?

3. Secure permission to prune some of the trees in your community as a demonstration. Keep records on the time and cost of pruning. Leave some trees unpruned, and note the difference in wood growth and color of fruit at picking time.

4. Find two orchardists in your community, one who prunes heavily and one who prunes lightly, and note the comparative size of trees of the same age and variety in the different orchards. Determine which trees bear the earliest and most fruit.

5. Select one or two old apple trees in your community, and give them a rejuvenation pruning; have them fertilized if possible, record the yields of fruit, and use them as a demonstration to encourage the better care of old trees.

CHAPTER VI

CONTROLLING INSECTS AND DISEASES

The control of insects and diseases is one of the major problems of the fruit grower. The destructive work of these organisms reduces both the quantity and the quality of the fruit, the vitality and life of the tree may be impaired, and the investment in materials, equipment and labor to control them constitutes one of the chief items of expense in fruit production.

Insects and diseases cause annual losses that run into staggering sums. First is the direct loss from the work of the organisms, and then the expense of materials and labor, of investments in equipment, in order to control them, as well as the reduction in vitality of the tree or plants, affecting productivity and perhaps length of life. One authority states that from 20 to 40 percent of the fruit crop in the United States is destroyed each year by insects alone. The problem is not merely to find materials that will control but materials that the grower can afford to use and that will control the organisms without injury to the fruit plant.

Most kinds of fruit cannot be changed from one field to another on a short rotation, as may be done with annual crops. An apple orchard is fixed for the better part of a lifetime. The fruit grower cannot employ rotation as one of his major weapons in insect and disease control, as is frequently done with annual crops.

There are natural forces which exert a measure of control over insects and diseases. Late frosts, cold winters, dry spells all have their effects. Diseases among insects, predaceous and parasitic insects and even birds may greatly reduce the numbers of prospective pests. These agencies and factors have a bearing on the situation but the grower cannot rely upon them to solve his problem.

Spraying involves the application of materials in dust or liquid form to fruit plants as a preventive and combative measure against the attacks of insects and disease. However, though the grower may resort to other measures at times, his main reliance is found in the spraying program.

Operations:

1. Determining insects and diseases to be controlled.
2. Selecting and preparing materials for control.
3. Determining time of application of materials.
4. Selecting machinery and equipment for making applications.
5. Applying materials.
6. Determining costs of spraying program.
7. Adopting control measures other than spraying.

1. Determining Insects and Diseases to Be Controlled. The grower must know the major organisms that are destructive and injurious to his fruit enterprise before he may proceed intelligently with their control.

He need not know each intimate detail of their life histories. He may well leave such studies to the trained entomologists and plant disease workers attached to the experimental stations that serve his section. Certain pests, however, are standard in the sense that they are present each year and sufficiently serious to require control measures. Others are standard but seasonal, being present and destructive only under certain conditions. The grower must know these standard pests and the conditions governing their presence, and he must be able to recognize the evidences of their presence.

Procedure:

(*a*) Consider the feeding habits of insect pests.
(*b*) Consider the nature of disease attacks.
(*c*) Consult experiment stations and other sources for complete information.

(*a*) *Consider the Feeding Habits of Insect Pests.* Control of insect pests may best be approached from a study of their methods of feeding. *Chewing* insects possess hard mouth parts with which they bite off portions of the leaves, plant, fruit, etc., actually taking some of these materials into their bodies. The tent caterpillar and codling moth are illustrations, both being destructive in the larval stage. The former

FIG. 100. Some insects with biting mouth parts. (*a*) Grasshopper. (*b* and *e*) Beetles. (*c* and *d*) Sawfly larvae. (*f*) Caterpillar.

feeds chiefly on the leaves, the latter chiefly on the fruit. See Fig. 100.

Sucking insects possess mouth parts in the form of a beak or slender tube which they insert beneath the exterior surface of the object on which they are feeding, drawing or sucking the juices from within the tissues. The San José scale and aphids, or plant lice, are examples. The mosquito illustrates the same type of feeding on human beings. See Fig. 101.

Other insects possess mouth parts which permit them to lap or lick up liquids from the outer surfaces of the object on which they feed. The adult fly of the apple maggot and the cherry fruit fly are illustrations.

As the insect passes through different stages of development (metamorphosis), it may possess different types of mouth parts. The larva or worm has biting mouth parts whereas the adult moth may lap up its food as in case of the apple maggot.

(*b*) *Consider the Nature of Disease Attacks.* Fruit dis-

FIG. 101. Some insects with sucking mouth parts. (*a, b, c, d, e*) Scale insects. (*f*) Leafhopper. (*g*) Plant Bug. (*h*) Aphids.

eases, with a few exceptions, are of the fungus type, plant forms lacking the chlorophyll or green coloring matter of common plants and existing as parasites in or on the tissues of living plants. Apple scab and bitter rot are examples. Propagation takes place by means of the development of seed forms called spores. The wind—including even light air currents—rain, insects, and other agents are responsible for their dissemination. Fungi need moisture for a period in order to develop from the spore stage and to establish themselves upon the host. The time of application of control measures is influenced by this fact.

Some fruit diseases, as fire blight of apples, pears, and quinces, are caused by bacteria rather than fungi. Since they are already established on the host before their presence is detected, and since any materials that would control them would also injure the host plant, they must be fought by methods other than spraying.

Various physiological diseases as bitter pit, drought spot, and cork are apparently associated with poor moisture conditions, and injury from these troubles is reduced when moisture conditions of the soil are improved.

(*c*) *Consult Experiment Stations and Other Sources for Complete Information.* The experimental stations and colleges of agriculture are public agencies, established in the various states. They are prepared to furnish the latest and most dependable information available with regard to the insects and diseases that trouble the grower. The grower should establish and maintain contact with these institutions as a safeguard and insurance.

The commercial grower cannot afford to turn a business enterprise into an experimental project. He may, however, cooperate with public agencies in conducting field laboratories, tests, and demonstrations that have for their object the acquirement or dissemination of greater knowledge, which in turn will bring a larger return to the grower.

2. Selecting and Preparing Materials for Control. Materials suitable for controlling certain insects may be ineffective against others, and may be useless for the control of diseases. Some materials possess valuable properties for both insect and disease control. Some are effective, but cost so much that the grower cannot afford to use them; others are effective and acceptable as to cost but cause injury to the plant or fruit under certain conditions. New materials are continually being put forward, and the grower must decide whether or not he will discard the old and adopt the new.

He should base his decision on known facts in order to proceed with judgment and with as little risk as possible.

Procedure:

(*a*) Consider materials for insect control.
(*b*) Consider materials for disease control.
(*c*) Consider agents that increase spreading and sticking qualities of materials for insect and disease control.
(*d*) Consider preparation of materials at home or their purchase from commercial concerns.
(*e*) Select materials for a complete program.

(*a*) *Consider Materials for Insect Control.* Materials used to control insects are termed *insecticides.* For biting and chewing insects, a stomach poison is applied to the material on which they feed.

For sucking insects, materials which suffocate, burn, or paralyze them are used. These are called *contact insecticides,* since they are applied directly to the bodies of the insects. It is evident that a stomach poison applied on the exterior surfaces of the materials on which sucking insects feed would not prove effective.

Insects with lapping mouth parts may usually be controlled with stomach poisons since they take up their food from the outer surfaces.

Stomach Poisons

a: 1. *Lead arsenate* is the stomach poison in common use. Its active agent is white arsenic. White arsenic alone will cause burning of fruit and foliage; it is therefore combined with lead to reduce this danger.

Lead arsenate is known as "acid," or "basic," depending upon the nature and proportion of the lead-carrying material combined with the white arsenic. The acid lead arsenate is in more common use and is sometimes called "standard" arsenate of lead. Basic lead arsenate contains less arsenic, is more stable and less likely to cause burning, but is slower in its action than the acid form. However, if used according to directions, the acid lead arsenate is not likely to cause burning in most parts of the country. In California it has caused severe burning, when used with hard or alkaline water.

Lead arsenate may be purchased in either powder or paste form, the paste form differing from the powder only in containing about 48 percent of water. Most paste arsenates are of the acid type.

Objections to the paste form of lead arsenate are its bulk and consequent increased freight and handling costs; the tendency of the water to separate out, making it difficult to mix before using and affecting the accuracy of the measurements; the tendency of the water to dry out of the mixture, leaving it more concentrated than the analysis indicates; and the possibility of leakage and bursting of the package, as a result of freezing. Consequently the powder form is more commonly used. It is colored a pale pink by most manufacturers so that it cannot be mistaken for some non-poisonous compound.

Arsenic in any form is an active and virulent poison when taken internally. It should be stored and handled with this in mind. So far as external effects are concerned, it may be handled freely by the operator.

a: 2. *Calcium Arsenate.* Among other stomach poisons for chewing insects, arsenic in combination with calcium as *calcium arsenate* is on the market. It is cheaper pound for pound than lead arsenate and carries a higher arsenic content. It is available in both paste and powder forms. As constituted at present, it is not safe to use on stone fruits since it causes severe burning. It also burns apple and pear foliage in some sections.

In planning a spray program which offers the maximum of protection against insect pests without leaving excessive spray residue, calcium arsenate is recommended in some sections as a substitute for lead arsenate in some of the cover sprays. Add 3 pounds of hydrated lime to every pound of calcium arsenate to decrease or prevent burning of the foliage.

The calcium arsenate should be fresh and of a brand which is stated by the manufacturer to be suitable for orchard spraying.

a : 3. *Zinc arsenate* is sometimes used as a substitute for lead arsenate. It is somewhat safer than calcium arsenate as long as 1 pound of lime is used for every pound of zinc arsenate.

a : 4. *Less Common Stomach Poisons.* At the present time experimental work is in process with a group of new stomach poisons for orchard use. Hellebore, cuprous thiocyanate, dinitro-*o*-cresol, and thiodiphenylamine (phenothiazine) are some of the most promising. As yet none of these materials is replacing the common arsenic compounds.

It is certain that investigations will continue until materials both effective and economical, lacking the burning properties of arsenic compounds and the undesirable accumulation of poisons (spray residues) on the fruit, are developed. Progress in this direction should be watched carefully. In the meantime follow the recommendations of your local experiment station.

Contact Insecticides

a : 5. *Lime-sulfur* is a standard insecticide for sucking insects which must be fought with a contact application. It is a solution looking much like a red-brown syrup, obtained by boiling together fixed amounts of burned or stone lime, sulfur, and water. It is much used for control of San José scale. It is one of the safest and best sprays to use in the dormant season when the foliage is off, and has no bad cumulative effects from years of use. It is not in common use as a summer spray for insects, since on most trees it would injure the foliage, or even cause defoliation, at dilutions strong enough to be effective. It is used extensively for the summer control of fungus diseases.

The manufacture of lime-sulfur, or concentrated lime-sulfur, as it is often called, is well standardized. It is available from many commercial concerns, being supplied usually in drums or barrels holding 50 gallons. Its strength is determined by means of the Baumé test, the instrument employed being the hydrometer. This records the density or specific gravity of the solution. The commercial product should test at least 32° Baumé; it frequently tests 33°. There should be no sludge or precipitate in the bottom of the barrel.

a : 6. *Dry lime-sulfur* is obtained by dehydrating or extracting the moisture from concentrated lime-sulfur containing some stabilizer, like cane sugar. It is mixed with water before using. It is cheaper to transport and easier to handle than concentrated lime-sulfur. It is not so powerful an insecticide at the strengths recommended by the manufacturers as concentrated lime-sulfur, and at present prices is more expensive on the basis of active ingredients. It seems necessary to use it in larger amounts for effective results than the manufacturers recommend at present.

a : 7. Tobbacco preparations are valuable contact insecticides. Nicontine is the effective agent. It is a powerful, quickly acting poison, very toxic to many insects. These preparations may be used on tender foliage without injury. They are employed extensively for the control of aphis and red bug.

The common commercial form is a concentrated solution containing 40 percent of *nicotine sulfate*; other preparations containing different proportions are also available.

The value of nicotine sprays is affected largely by temperature changes and the hardness of the water used for dilution. They function best at warm temperatures and when the air is quiet enough so that the fumes generated do not dissipate rapidly. Hard water increases the toxic effect of the application. Soap is often added to increase the spreading properties of the material.

Most nicotine trade names give an indication of the percentage of nicotine present, for example "Black Leaf 40."

Tobacco preparations in dust form are also available. They are used extensively on vegetable crops and to some extent for fruit. They have been developed recently and their use is likely to expand as they are further perfected.

Tobacco dusts are obtained by impregnating some suitable carrier, as hydrated lime, with free nicotine or nicotine sulfate, or by grinding tobacco refuse into a fine powder. Tobacco refuse gives dust of an uncertain strength and effectiveness. Some growers make their own dust from hydrated lime and nicotine sulfate.

Dusts made with free nicotine are more volatile and quicker in their action than those made from nicotine sulfate containing 40 percent nicotine. This is an advantage since insects succumb more readily to the dusts of higher volatility. Such dusts, however, are more expensive than those of slower action. The strength of nicotine in these preparations is expressed either as the percentage of actual nicotine in them, or the percentage of nicotine sulfate, which is but 40 percent nicotine. A 2 percent nicotine dust is thus nearly 2½ times as strong as 2 percent nicotine-sulfate dust. (Nicotine is about 95 per cent pure.) This difference should be carefully noted in making calculations.

Nicotine dusts should be purchased in tight containers. The containers should be kept closed and as nearly full as possible, because the dusts lose strength rapidly on exposure to air.

a : 8. *Oil sprays* possess considerable insecticidal value. They spread well, permeating every crack and crevice. Their use is limited, however, because of their caustic effect upon the foliage and tender bark and because they cannot be used in combination with any sulfur sprays. They do not corrode metal parts of a sprayer but cause the rubber parts to deteriorate rapidly. Oils may not be used in freezing weather, or upon stone fruits at any season.

Emulsification. So that the oil may mix freely with water for dilution in a spray tank, a third material, an *emulsifier*, is added. Several emulsifying agents are on the market under trade names. They may serve as spreaders and stickers as well. They are in a liquid or powder form and usually have a soap or casein base. Bordeaux mixture is an excellent emulsifier and may be used as a fungicide in the same application. A *miscible oil* is a clear oil which contains an emulsifying agent and will mix when poured into fresh soft water. An *oil emulsion* is a grayish white cream which contains an emulsifying agent and consequently may be diluted with water. These two are the most popular forms of commercial orchard spraying oils.

Kinds of Oil

Petroleum oil is used to control lecanium, San José, and scurfy scale; for cleaning up bad outbreaks of leaf roller; to check pear psylla, European red mite, and probably apple red-bug eggs. It is used for dormant spraying only, and if applied for too many years in succession it may injure the tree. Petroleum oil may be bought as a crude oil, in a miscible form or as an emulsion.

Tar oil, a coal-tar creosote product, usually sold as an emulsion, is used to control aphid eggs, bud moth, oyster shell scale, and scurfy scale. It is not effective against San José scale. This oil is very caustic to the skin, and if the weather is at all windy during spraying, it must be handled with care. It is applied during the dormant period.

D.N. oil has been used as a dormant spray with some degree of success. D.N. is an abbreviation for the mixture of 96 percent by weight of lubricating oil and 4 percent of dinitro-orthocyclohexylphenol. As yet it should be used cautiously until more experimental wcrk has been done.

Tar lubricating oil, a mixture of tar oil and petroleum oil in various proportions, is sold by some manufacturers; it is used as a complete "clean-up" dormant application. It may be mixed and diluted so that there will be the proper amount of each type of oil to control the combination of insects which are attacking the trees (see Table 40, page 290). Tar lubricating oils are very dangerous if the buds have swollen, if the material is not properly emulsified, or if the mixture is not fresh. Otherwise they give good results.

White oils are highly refined mineral oils which have been used on summer foliage and possibly have a place in the spraying program of the future. Their greatest disadvantage is that they burn foliage which carries a sulfur residue.

This whole subject of the effectiveness of oil sprays of various types and the proper time of application is now in a state of flux. Interest is keen, and developments should be watched carefully. A report on the subject (Table 39) issued by the New York Agricultural Experiment Station at Geneva indicates the present status of oil sprays in early spring applications. The desire is to use some economical, safe material that will control as many pests as possible in the smallest number of applications.

a : 9. Soaps in combination with water possess insecticidal properties. They are seldom used alone but rather as constituents of oil emulsions or miscible oils, or in nicotine sprays to increase their spreading properties and liberate the nicotine. Potash fish-oil soap is the common form. Soda fish-oil soap will not dissolve so easily. Resin fish oil will not curdle in hard water.

a : 10. *Less Common Contact Insecticides. Pyrethrum* is a powder made from the flower heads of three species of pyrethrum plants. It is non-poisonous to warm blooded animals, but it loses its toxic properties upon exposure and it is difficult to find methods of standardization. *Rotenone* is both a contact and stomach poison which is harmless to warm-blooded animals. It is found in the roots of the derris plant in the Malay Peninsula and in cubé which grows in Peru. Although it is known to be a very good insecticide, its use is limited because of the cost of importing the raw material. Elgetol is a bright yellow dyestuff which is of value as an insecticide and ovicide and for which claims are made as a fungicide. It has been used thus far chiefly in the dormant or "bud-break-

TABLE 39

Early Spring Treatments for Apple Pests*
New York Agricultural Experimental Station, Geneva

Materials in Amounts per 100 Gallons of Spray Mixture	Cost per 100 Gallons of Spray Mixture†	Pest To Be Controlled							
		European Red Mite	San José Scale	Oyster Shell Scale	Scurfy Scale	Rosy Aphid	Red Bug	Bud Moth	Leaf Roller
Dormant Applications									
Lubricating oil, 3 gal.	0.64	E	E	P	P	N	N	P	N
Lubricating oil, 5 or 6 gal.	1.04 or 1.27	E	E	EI	E	P	FV	F	E
Tar oil, 3 gal.	1.26	N	N	F	F	E	N	P	N
Tar oil, 4½ gal.	1.89	N	N	E	G	E	N	F‡	N
Tar oil, 2½ gal. + lubricating oil, 3 gal.	1.70	F	G	E	E	E	P	F‡	N
Dowspray Dormant 2½ to 3 gal.	1.75 to 2.10	VI	VI	E	E	E	F	E	P
Elgetol, 1 gal.	2.00	VI	VI	E	E	E	N	E	N
Elgetol, 1 gal. + lubricating oil, 3 gal.§	2.65	—	—	—	—	EI	—	—	GI
Breaking-Bud Applications									
Elgetol, 1 gal.	2.00	VI	—	—	—	E	N	E	N
Green-Tip Applications									
Lubricating oil, 3 gal. + nicotine, 1 pint.	1.56	E	E	—	—	G	N	G	N
Delayed Dormant Applications									
Lubricating oil, 3 gal. + nicotine, 1 pint + Bordeaux.	1.51 ‖	E	E	—	—	G	N	G	N
Nicotine, 1 pint and lime-sulfur, 2½ gal., or wettable sulfur at manufacturer's recommendations.	0.91 ‖	N	N	N	N	G	N	G	N

* The letters represent the following control: E, excellent; G, good; F, fair; P, poor; V, variable (sometimes good or excellent control, in other tests fair to poor); N, not sufficiently effective to be practicable, and I, results based on insufficient evidence to be conclusive. A blank space indicates that no data are available.

† Based on the following price per pound, pint, or gallon; Goulac or Binderine (lb.), 3½c; lubricating oil (gal.), 20c; tar oil, 83% emulsion (gal.), 35c; nicotine sulfate (pt.), 91c; Dowspray Dormant (gal.), 70c; Elgetol (gal.), $2.00.

‡ Should not be used where infestation is severe.

§ Limited tests. Growers might test it experimentally where leaf roller, bud moth, and aphid occur in the same orchard.

‖ Cost of insecticide only, as fungicide cost will vary with amount of material used.

ing" stages. Though its use is as yet experimental, it is possible that some of the pre-blossom sprays may be omitted if Elgetol proves to be effective and desirable.

(*b*) *Consider Materials for Disease Control.* Materials used to control fungus diseases are termed *fungicides.* The active agents in most of these materials are sulfur or copper. Lime is commonly added to neutralize any caustic action that might attend their use. Fungicides prevent germination of the spores and the establishment of the fungus upon the host.

b : 1. *Lime-sulfur,* or concentrated lime-sulfur, is used very extensively for the control of fungus diseases. It is described under "Contact Insecticides," a : 5.

In some sections its use has resulted in a burning of the leaves and a russeting of the fruit. The advice of the experiment station serving the section in which the fruit enterprise is located is usually the best guide.

b : 2. *Bordeaux mixture* is a combination in certain proportions of copper sulfate (blue stone or blue vitriol), burned lime or quicklime, and water. Thus a common formula is 4–4–50, i.e., 4 pounds of copper sulfate, 4 pounds of burned lime, and 50 gallons of water.

There is a decided tendency now in practice to include an additional unit of lime as a further safeguard against burning. Thus, 4–5–50 and 3–4–50 are common formulas among fruit growers.

Bordeaux mixture is a stronger fungicide than lime-sulfur but under some atmospheric conditions may cause severe burning of fruit and foliage. Some varieties are more susceptible than others. In apples, the greatest injury occurs while the apple is young and held erect on the blossom stalk. It is evidenced by a russeting of the fruit and in severe cases by subnormal or abnormal development. Bordeaux mixture does not seem safe as an apple spray in New England, New York, or New Jersey. It is used quite extensively on apples in Nova Scotia and in Virginia.

Commercial forms of Bordeaux, both paste and powder, are available. In general, these are not so desirable as the freshly made material. They do not adhere so well to the fruit and foliage, are usually less effective as fungicides, and their cost is considerably in excess of that of the home-made preparation. The commercial forms are useful for the home garden where small amounts are required.

Bordeaux mixture combined with lead arsenate is also available commercially as a fungicide and insecticide. Determine from the analysis the amount of water-soluble arsenic. It should not exceed ½ of 1 percent, or severe burning may follow its use. Use the preparation at such strengths as to give the standard applications of both materials.

b : 3. *Sulfur* used alone in dust form is a good fungicide. It seldom causes burning. It should be at least 98 percent pure, and the particles should pass through a 300-mesh sieve (300 meshes per inch, 90,000 per square inch). Fineness of division adds much to its adhesiveness and consequent effectiveness, and coarse dusts should never be used.

Sulfur dust alone, or in combination with powdered lead arsenate and lime dust, is used quite extensively for the summer control program on apples, pears, peaches, and cherries.

b : 4. *Wettable sulfurs* possess fungicidal value. They are mixtures of sulfur with a flux which makes them compatible with water. Dextrin, flour, glue, and calcium caseinate are some of the materials with which the sulfur is mixed. Flotation sulfur paste is a good example of this type of fungicide. Although each manufacturer gives his own directions, usually the diluted spray should contain from 6 to 8 pounds of actual sulfur in 50 gallons of water and if used in conjunction with arsenicals about 2 to 4 pounds of lime to each pound of arsenical. This type of fungicide is much easier on foliage than lime-sulfur. Not only is it unlikely to cause burning, but also it allows the tree to develop larger and more healthy foliage. In other words, it exerts no inhibiting effects. It is not so strong a fungicide as lime-sulfur. In very wet periods it is not recommended to replace lime-sulfur. Wettable sulfurs are sold under many different trade names. Purchase from a concern of established reputation.

b : 5. *Self-boiled lime-sulfur* is effective in the control of brown rot of the peach and other stone fruits, and is used for this purpose by many growers in the peach regions from New England southward. It is a very safe form of sulfur from the standpoint of injury to fruit or foliage. As the name implies, its preparation is due to the action of the lime when slaked. The formula is 8–8–50: 8 pounds of burned lime, 8 pounds of sulfur, and 50 gallons of water. The active agent is the sulfur; the lime reduces the danger of burning.

b : 6. *Dry mix or New Jersey dry mix* is the name given to a sulfur-lime mixture used as a substitute for self-boiled lime-sulfur for stone fruits and also as a summer spray for apples in some sections. It is easier to prepare than self-boiled lime-sulfur. Dry mix is not so strong a fungicide as concentrated lime-sulfur and may not be advisable as an apple spray for the early applications in some seasons. It does not cause the burning that sometimes results from lime-sulfur. It is mixed in the dry state and combined with water before using. In order to make the mix wettable, calcium caseinate or powdered skim milk is added to the sulfur and lime. The usual formula is 8 pounds of sulfur, 4 pounds of hydrated lime (finely ground finishing lime), and ½ pound of either calcium caseinate or powdered skim milk to 50 gallons of water. One-half pound of bread flour may be substituted for the caseinate or skim milk.

Arsenate of lead or nicotine preparations may be used with this material. For use with arsenate of lead, double the amount of lime.

b : 7. Other forms of sulfur as *colloidal sulfur, barium tetrasulfide*, etc., are available, and still others are being perfected and put forward each season. All have some, many have considerable, value. The grower will do well, however, not to displace the standard materials until new ones receive the endorsement of his experiment station.

b : 8. *Copper sulfate dust* has been used in conjunction with lime as a fungicide for apple sprays in Canada. Farther south, severe burning has resulted. It is used extensively by vegetable growers.

(*c*) *Consider Agents That Increase Spreading and Sticking Qualities of Materials for Insect and Disease Control.* Materials are sometimes introduced into the spray formula, not because of their value as effective agents in themselves, but because they affect favorably the physical properties of insecticides and fungicides. They increase the spreading qualities of spray materials, giving greater uniformity in coverage, or increase the adhesiveness or sticking qualities of the spray materials, making them effective over longer periods.

Various milk products have been used in recent years in this connection. Casein is the effective agent in the milk products. Although most experiment stations make favorable reports on spreaders, some experimental results have shown disagreement with these findings. In the meantime, growers in general are not using these products extensively on account of their cost and because they have felt that the benefits were not very marked. Further tests and findings should be considered carefully.

c : 1. *Calcium caseinate* contains about 20 per cent casein and 80 per cent of hydrated lime. It is on the market under various trade names, to be combined with lime-sulfur, Bordeaux, and arsenical sprays. Dilutions of 1 to 2 pounds per 100 gallons are recommended.

c : 2. *Skim milk* has been used as a substitute for calcium caseinate. General recommendations for all fruits indicate its use at a rate of 1 gallon to 100 gallons of spray.

c : 3. *Flour,* finely ground and of at least 12 per cent gluten content, has given excellent results. Any standard bread flour meets the requirements; pastry flours and the coarse flours do not. Flour is entirely safe with all materials, giving no chemical reaction. It is used at the rate of 1 to 2 pounds to each 100 gallons of spray. Soybean flour and lime (1 pound of each to 100 gallons of the mixture) have given good results.

c : 4. *Lignin pitch* is used with lead arsenate and lime-sulfur combinations and as an emulsifier for home-made lubrication oil emulsions. It is applied at the rate of ½ pound to 100 gallons of the mixture.

(*d*) *Consider Preparation of Materials at Home or Their Purchase from Commercial Concerns.* Whether or not materials for the spraying program should be made at home depends on the complexity of the processes of manufacture, the quantities of spray materials required, the equipment needed, and the final saving in cost over the prepared product. Some materials deteriorate on standing and should be prepared just prior to their use. Others may be prepared in advance and stored until needed. It is not feasible to attempt to manufacture arsenate of lead at home. The same is true of the tobacco preparations, with the exception of the dusts which are sometimes prepared by growers using them in large quantities.

d : 1. Consider the preparation of lime-sulfur. Lime-sulfur may be prepared at home. It is made by large growers in some sections, especially where the freight rates on the commercial products are high. The equipment needed is not extensive.

A common formula is:

Burned or quicklime	50 pounds
Sulfur	100 pounds
Water	50 gallons

Experiment stations will furnish directions for making.

Commercial forms of lime-sulfur are now so well standardized, however, so uniform in test, and produced in such enormous quantities that many growers prefer to use them.

d : 2. Consider the preparation of Bordeaux mixture. This is commonly made by the grower if needed in any quantity. A common formula is 4–4–50, containing:

Copper sulfate	4 pounds
Burned lime or quicklime	4 pounds
Water	50 gallons

The formula may be 3–3–50 or 5–5–50, etc., varying the proportion of lime and copper sulfate to the water. One unit more of lime than of copper sulfate, as 4–5–50, gives additional insurance against burning and is frequently used by growers.

Prepare a stock solution by dissolving the required amount of copper sulfate crystals at the rate of 1 pound of copper sulfate to a gallon of water. Put the copper sulfate in a sack at the surface of the water, using a barrel or other wood container for the water. As the chemical dissolves, being heavier than water, it will work toward the bottom, keeping water in contact with the sack. If the sack is put in the bottom of the barrel, the material will dissolve much more slowly. Start the process at any convenient time before the material is to be used, since it will keep indefinitely.

Slake the required amount of lime, adding water slowly so that the lime breaks down into a fine powder and then into a smooth milky mixture. Add water until the proportions are 1 part of lime to 1 gallon of water. Keep the mixture covered.

It is evident that for a 4–4–50 formula it is only necessary to take 4 gallons of each stock solution to a 50-gallon unit. For a 200-gallon spray tank, using this formula, 16 gallons of each stock solution would be required.

If large amounts of stock solution are needed, prepare the copper sulfate at the rate of 2 pounds to a gallon of water. If only small amounts are required, use hot water in slaking the lime, since cold water on a small quantity of lime may check the slaking process. The solutions will keep indefinitely so long as they are not mixed. Keep them covered to prevent evaporation of water from them, since this would change the strength of the stock solutions and lead to errors in making dilutions. Put a few drops of oil on the surface of the stock solutions to prevent evaporation, or replace the water that has evaporated, before using.

In combining the materials for spraying, never put the stock solutions together, as the materials will curdle and settle rapidly in the form of coarse particles. "Put the water between" is an axiom in preparing Bordeaux mixture. A good method is to put the copper sulfate solution in the tank and add water until the tank is about two-thirds full. Start the agitator. Stir the lime mixture thoroughly, and strain the correct amount into the tank, washing it in gently with a hose. Fill the tank with water and spray out at once, keeping the tank well agitated. If the mixture must be kept several hours or longer, add a heaping tablespoonful of ordinary cane sugar dissolved in a little hot water to each 100 gallons of spray material. This will cause it to keep in good condition indefinitely.

Unless sufficient lime is present to neutralize the copper, burning of fruit or foliage may result. The formula is intended to provide the necessary lime content, but nevertheless the grower should test the material. Hold a clean, polished knife blade in the diluted preparation for a moment. If no copper is deposited on the blade, the mixture is safe. The potassium ferrocyanide test may also be used. If a drop in the spray material gives a brown or red reaction, the lime is insufficient. If the reaction is yellow, the lime is sufficient to neutralize the copper.

Hydrated copper sulfate in powder form may now be obtained and poured directly into the tank, adding the lime as directed. This eliminates making the stock solution of copper sulfate, and it is claimed that results are equally satisfactory.

Hydrated lime in a very fine state of division may be substituted for the burned lime, but is more expensive at the present time. It requires 66 pounds of hydrated lime to equal each 50 pounds of the burned lime in the stock solution.

For the preparation of Bordeaux mixture in large quantities and for rapid work in the spraying season, an ample water supply is essential. An elevated mixing platform from which the materials pass by gravity is desirable. The spray tank should be equipped with a large copper or bronze strainer with at least 16 meshes to the inch, through which the materials pass into the tank.

Pipes and hose should be at least 2 inches in diameter to permit the quick performance of all operations. The stock solution tanks should be large enough to hold materials for a full day's spraying.

Another method which may be used without a platform is to fill the spray tank about three-fourths full with water. Dilute the copper sulfate stock mixture with part of the remaining water, start the agitator, and pour the copper sulfate into the tank; dilute the stock solution of lime with the balance of the water, and pour it into the tank.

Bordeaux mixture will attack iron and steel. Use brass, bronze, or porcelain-lined spraying equipment where possible, and flush it out with clean water immediately after use.

d : 3. Consider the preparation of tank-mixed lubricating-oil emulsions. The Cornell Experiment Station at Ithaca, New York, gives the following directions for tank mixed emulsions.

The tank-mixed emulsions are prepared by several formulas. Many growers prefer to emulsify the oil in the tank, using lignin-pitch as the emulsifier. With the agitator running, put about 10 gallons of water in the tank or enough so that pump can work. Wash ½ pound of lignin-pitch through the screen by means of the spray gun. When it is thoroughly dissolved in the water, add the proper quantity of oil slowly with the agitator running and with the spray gun turned into the tank. When it is emulsified, add the full amount of water and spray out at once. The quantity of lignin-pitch required will depend on the water used. If the mixture foams too much, reduce the quantity.

Another method is as follows: Place sufficient water in the spray tank so that the pump can work. Do not start the engine. For each 100 gallons of spray, add 1 pound of copper sulfate dissolved in water, then add 2 pounds of hydrated lime also in water, stirring meanwhile with a stick or paddle. Start the engine, and slowly pour in the proper number of gallons of oil to give the percentage desired in the completed mixture. Direct the spray gun into the tank and continue the agitation until the oil is properly emulsified. In a few minutes or as soon as the oil is thoroughly emulsified, fill the tank with water, keeping the engine running continuously until the tank has been sprayed out. If it is necessary to stop the sprayer, and any considerable quantity of oil separates out (streaks of free oil floating on the surface), the remainder in the tank should be discarded unless it can be brought back into an emulsion. If more copper is desired for fungicidal purposes, use 3 or 4 pounds of copper sulfate and twice as many pounds of hydrated lime.

Table 40 gives a dilution table for tar-distillate emulsions.

TABLE 40

DILUTION TABLE FOR TAR-DISTILLATE EMULSIONS*

Percentage of Oil in Stock Emulsion as Purchased		Number of Gallons of Emulsion to Be Used for 100 Gallons of Spray Mixture		
Tar Oil	Petroleum Oil	For Cherry Aphis (2 per cent tar oil)	For Rosy Aphis (2½ per cent tar oil)	For Scurfy Scale, Bud Moth, or Oyster-Scale-Shell (4½ per cent tar oil)
95	0	2.1	2.6	4.8
85	0	2.3	2.9	5.3
83†	0	2.4	3.0	5.4
80	0	2.5	3.1	5.6
75	0	2.7	3.3	6.0
65	15	3.1	3.8	6.9
60	23	3.3	4.2	7.5
50	33	4.0	5.0	...
40	40	5.0	6.3	...
37†	46	5.4	6.8	...
36	44	5.6	6.9	...

* 0.1 gallon equals approximately ¾ pint.

† These two oils are the ones most commonly offered for sale in New York State.

(*e*) *Select Materials for a Complete Program.* From his knowledge of the insects and diseases to be controlled and of the materials used for their control, the grower is in position to make up his spraying program. He should then decide which materials he will purchase and in what forms, and which he will prepare himself.

He knows that certain materials may be combined without detriment, thus controlling more than one pest at a time and reducing the number of applications needed. Others cannot be combined without changing the materials physically, making it difficult to apply them, or changing them chemically, resulting in injury to tree, fruit, or foliage.

The grower will purchase his materials well in advance of the spraying season at a time when the market is most favorable. This is usually in early winter. The materials should be stored in such a way as to make them convenient of access and to prevent mistakes in identification of materials and the possible use of the wrong material. Where unskilled help must be employed, especial precautions should be taken to prevent such mistakes.

3. Determining Time of Application of Materials and Amounts to Use. The grower knows that chewing insects are controlled best with stomach poisons. These may be applied before the insects appear and within comparatively wide and somewhat flexible limits.

Sucking insects, on the contrary, requiring contact sprays, must be fought with materials applied directly to them. The applications, therefore, may be made only when the insects are present and usually within narrow time limits.

Fungus diseases require the presence of moisture for an extended period to enable the spores to germinate and the organism to establish itself. Since control measures are ineffective after the fungus is once established on the host, it has become a rule in fruit growing to apply fungicides before rainy weather.

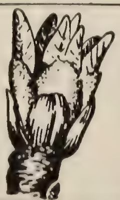
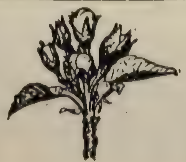
Consult Spray Program for the Region. Experiment stations have developed spray programs or schedules adapted to certain sections, which through a combination of insecticides and fungicides will control most of the common insects and diseases with a minimum number of applications. Become familiar with the program for your section. Follow it carefully. Since new or more complete information is appearing each year, the program is subject to change, and the grower must be continually on the watch for better and less expensive methods of accomplishing his purposes.

MICHIGAN AGRICULTURAL EXPERIMENT STATION SPRAY SCHEDULE, 1939

Michigan Extension Bulletin 154 (Revised 1938)

Apples

Sections mentioned under Explanations refer to supplemental material in bulletin

Stage of Growth	Application	Materials	To Control	Explanations
	1. *Dormant.* Complete before green tips appear.	Lime-sulfur (dormant strength), tar, and oil or an oil spray. Refer to Sections 28 and 33 to 36 for specific instructions.	Scale insects, mites, and leaf-rollers. Lime-sulfur will control scale insects, but oil will also control scale and is necessary for mites and leaf-roller. Tar and oil will control aphid, scale, and redmite. Oil containing DNOCHP* will control aphis and San José scale.	The dormant application of oil is necessary for the control of mites and leaf-rollers, and will also control scale. Lime-sulfur may be used if scale only is to be controlled. Refer to Sections 33 to 36 for specific instructions.
	2. *Delayed dormant.* Apply in a well-developed green-tip stage, when leaf tips are $\frac{1}{4}$ to $\frac{1}{2}$ inch in length.	Lime-sulfur $2\frac{1}{2}$ gal., lead arsenate 3 lb., nicotine sulfate 1 pt., and water to make 100 gal. These applications are the most important for scab control.	Scab, aphid, and bud moth. Omit the nicotine sulfate if a dormant application of DNOCHP* or tar and oil has been made.	This is the best period for the control of aphid, if this has not been effected by dormant applications, and the lime-sulfur that is necessary with the nicotine will prevent early infection of apple scab. Lead arsenate is partially effective against bud moth. Refer to Sections 37 and 38 for special instructions for the control of aphis.
	2a. *Pre-pink.* Begin soon after the delayed dormant condition and complete as soon as possible.	Lime-sulfur $2\frac{1}{2}$ gal., lead arsenate 3 lb., and water to make 100 gal.	Scab, curculio, and bud moth. If aphids have not been controlled by this time, nicotine should be added as satisfactory aphid control cannot be expected later than the pre-pink application.	Apply the pre-pink on the more susceptible varieties and on all varieties when conditions seem very favorable for scab development, or in seasons when bud development is spread over a long period. Still another application for scab control between the pre-pink and pink applications may be desirable under extreme conditions.
	3. *Pink.* Begin to apply as soon as most of the buds have separated in the clusters and complete before the blossoms open.	Lime-sulfur 2 gal., lead arsenate 3 lb., and water to make 100 gal.	Apple scab, curculio and other chewing insects.	This application is important for scab control. The lead arsenate is of value for the control of chewing insects, as well as increasing the fungicidal value of the lime-sulfur. Do not use lead arsenate after the blossoms begin to open. Bees may be poisoned and pollination of early bloom reduced.

	4. *Petal-fall (calyx).* Should be made when most of the petals have dropped and after bees have quit working in the bloom.	Lime-sulfur $1\frac{1}{2}$ gal., lead arsenate 3 lb., nicotine sulfate 1 pt., and water to make 100 gal. Nicotine sulfate may be omitted if red bugs are not prevalent.	**These are the important applications for codling moth control.**	Scab, codling moth, curculio, other chewing insects and red bugs. Wettable sulfur may be substituted at this time.	Spraying should not begin until most of the petals are off and there are no bees working in the trees, but should be completed as soon as possible. Refer to Section 40 for the control of red bug.
	5. *First cover.* Ten days after petal-fall.	Wettable or flotation sulfur 4 to 6 lb., lead arsenate 3 lb., and water to make 100 gal.		Codling moth, curculio, lesser apple worm, and scab.	
	5a. *Second cover.* Ten days after Application 5.	Lead arsenate 3 lb., zinc sulfate-lime (see Sec. 60), and water to make 100 gal.		Codling moth, curculio, lesser appleworm, and scab. If apple scab is prevalent, the use of wettable sulfur may be advisable at this time.	*Warning. Important* Govern use of lead arsenate during the summer by the prevalence of codling moths. Read carefully Section 31. If fruit is not to be washed, refer to Section 31.
	5b. *Third cover.* Two weeks after 5a.	Lead arsenate 3 lb., zinc sulfate-lime (see Sec. 60), and water to make 100 gal.		Codling moth, lesser apple worm, and curculio.	
	5c. *Fourth cover.* Two weeks after 5b.	Lead arsenate 3 lb., zinc sulfate-lime (see Sec. 60), and water to make 100 gal.		Codling moth, lesser apple worm, and curculio.	
	6. *Summer generation.* Exact time to be determined each year, usually about Aug. 1.	Lead arsenate 3 lb., zinc sulfate-lime (see Sec. 60), and water to make 100 gal. Add flotation sulfur or similar material if needed for scab control.		Codling moth, curculio, and scab.	The exact time of this application is determined by the Entomology Department, and announcement is made through county agents.
	7. Two weeks after Application 6, and if necessary make one or two more applications at two-week intervals.	Lead arsenate 3 lb.		Codling moth and curculio.	

This schedule will make residue removal necessary.

* DNOCHP = Dinitroorthocyclohexylphenol.

MICHIGAN AGRICULTURAL EXPERIMENT STATION SPRAY SCHEDULE, 1939—*Continued*

Pears

Stage of Growth	Application	Materials	To Control	Explanations
	1. *Dormant.* Apply with the first good spraying weather in March or early April.	Oil emulsion, 3% heavy oil, or a commercial oil spray.	Psylla, scale insects, and mites.	For the control of pear psylla use an oil spray as an early spring application before egg laying begins. Apply with the first good spraying weather. Refer to Section 47 for specific instructions.
	2. *Delayed dormant, or pre-pink.* Latter stage is shown at left.	Bordeaux 3-8-100 and lead arsenate 3 lb. in each 100 gal. Refer to Sections 16 and 17 for instructions for making Bordeaux.	Scab, leaf-blight, curculio, and bud moth.	This is good insurance against scab on any susceptible variety and should everywhere be made on Flemish Beauty or similarly susceptible varieties.
	3. *Pink.* Apply when the buds have separated in the clusters but before the blossoms have opened.	Bordeaux 3-8-100 and lead arsenate 3 lb. in each 100 gal. Refer to Sections 16 and 17 for instructions for making Bordeaux.	Scab, leaf-blight, curculio, and bud moth.	This should always be made in districts where scab is prevalent and everywhere on varieties such as Flemish Beauty In many parts of the state, however, scab is seldom serious on most varieties. In such cases measures for its control may not be necessary.
	4. *Petal-fall or calyx.* Just as the petals are falling.	Bordeaux 2-8-100 and lead arsenate 3 lb. in each 100 gal. of spray.	Scab, leaf-blight, codling moth, curculio, and other chewing insects.	
	5. *First cover.* Two weeks after petals fall.	Bordeaux 2-8-100 and lead arsenate 3 lb. in each 100 gal. of spray.	Codling moth, curculio, other chewing insects, scab, and leaf-blight.	Bordeaux may be omitted if scab and leaf-blight are not present. Refer to Section 47 for the summer treatment of psylla.
	5a. *Second cover.* Two weeks after Application 5.	Lead arsenate 3 lb. and water to make 100 gal.	Codling moth and curculio.	*Warning. Important*
	5b. *Third cover.* Two weeks after Application 5a.	Lead arsenate 3 lb. and water to make 100 gal.	Codling moth and curculio.	Govern the use of lead arsenate during the summer by the prevalence of codling moth. Read carefully Section 46.
	6. *Summer generation.* Time determined the same as for apples.	Lead arsenate 3 lb. and water to make 100 gal.	Codling moth and curculio.	Bordeaux may be used at this time on varieties very susceptible to scab. Read carefully Section 46

This schedule will make residue removal necessary.

MICHIGAN AGRICULTURAL EXPERIMENT STATION SPRAY SCHEDULE, 1939—*Continued*

Sweet Cherries

Application	Materials	To Control	Explanations
1. *Dormant.*	Lime-sulfur, oil, tar and oil, or oil DNOCHP.* See next column.	Scale insects (see Section 34). Leaf-roller (see Section 36). Case-bearer (see Section 57). Aphid (see Sections 19 and 28).	
2. *Petal-fall.* Just after petals have fallen.	Lime-sulfur 2 gal., lead arsenate 2 lb., and water to make 100 gal.	Leaf-spot, brown-rot, curculio, and slugs. (See Section 54 for aphid control.)	Avoid spraying sweet cherries during periods of high humidity and high temperature.
Two-weeks. Two weeks after Application 2.	Lime-sulfur 2 gal., lead arsenate 2 lb., and water to make 100 gal.	Leaf-spot, brown-rot, curculio, and slugs. (See Section 54 for aphid control.)	Lead arsenate should not be used later than this (before harvest) except on fruit that will go to the canning factory and will be thoroughly washed.
4. *Four-weeks.* Two weeks after Application 3.	Lime-sulfur 2 gal., lead arsenate 2 lb., and water to make 100 gal. Omit lead arsenate unless fruit is to go to canning factory or can be washed.	Leaf-spot, brown rot, curculio, slugs, and maggots. (See Section 54 for aphid control, and Section 55 for maggot control.)	Omit lead arsenate unless fruit is to go to canning factory or can be washed.
4a. *Special.* For the control of cherry maggot.	Refer to Section 55 for information concerning a special application for the control cf cherry maggot on canning cherries.		
5. *Brown rot.* About one week before picking.	Sulfur dust or spray of wettable sulfur.	Brown-rot.	See Section 52.

Residue removal. Instructions will be furnished on request to the Department of Horticulture.
* DNOCHP = Dinitroorthocyclohexylphenol.

MICHIGAN AGRICULTURAL EXPERIMENT STATION SPRAY SCHEDULE, 1939—*Continued*

Sour Cherries

Application	Materials	To Control	Explanations
1. *Dormant.*	Oil, or tar sprays (refer to Section 57).	Oil will control leaf-roller and case-bearer. Tar sprays will control case-bearer.	Instructions for control will be found in Section 57 for case-bearer and Section 36 for leaf-roller.
2. *Petal-fall.* When most of the petals have dropped.	Approved proprietary copper compounds (use according to manufacturer's recommendation); lead arsenate 2 lb. and water to make 100 gal. See Section 53.	Leaf-spot, brown rot, curculio, and slugs.	This application is important in checking the first infections of leaf-spot.
3. *Two-weeks.* Should be completed within two weeks after petal-fall.	Approved proprietary copper compounds (use according to manufacturer's recommendation); lead arsenate 2 lb. and water to make 100 gal. See Section 53.	Leaf-spot, brown rot, curculio, and slugs.	Lead arsenate should not be used later than this before harvest, except on fruit that will go to the canning factory and will be thoroughly washed.
4. *Four-weeks.* Should be completed within two weeks after Application 3.	Approved proprietary copper compounds (use according to manufacturer's recommendation); lead arsenate 2 lb. and water to make 100 gal. Omit lead arsenate unless fruit is going to canning factory or can be washed. See Section 53.	Leaf-spot, brown rot, curculio, and slugs.	Omit lead arsenate unless fruit is to go to canning factory or can be washed.
5. *After harvest.* Just after the fruit is harvested.	Approved proprietary copper compounds (use according to manufacturer's recommendation); lead arsenate 2 lb. and water to make 100 gal. See Section 53.	Leaf-spot and slugs.	

Special. On young growing trees extra applications may be necessary until growth is completed. Refer to Section 55 for special information on maggot control.

Residue Removal. Instructions will be furnished on request to Department of Horticulture.

Do not follow a copper spray with lime-sulfur for summer applications during the same year.

Typical spray schedules are incorporated herewith. They are not intended as guides but merely as illustrations. Schedules vary for different regions and for the various fruits. They vary also for the same regions in different years, depending upon climatic conditions, the evidence of an epidemic of disease or insect pests, and the acquirement of greater knowledge with respect to control.

In many schedules the proportions of lime-sulfur are given as 1–30, 1–40, 1–50, etc. This means that 1 gallon of a standard solution is used to 30, 40, or 50 gallons of water.

Proportions of lead arsenate are given in terms of the powdered form, unless otherwise indicated.

The term nicotine, unless otherwise defined, refers to nicotine sulfate.

SPRAYING SCHEDULES, NEW YORK STATE COLLEGE OF AGRICULTURE, 1939

Cornell Extension Bulletin 314 (revised, 1939)

Spray Outline for Apples

Dormant Spray. For the control of rosy aphis, tar-distillate emulsion containing 2½ percent of tar oil in the diluted mixture may be applied while the buds are dormant. If the amount of tar oil is increased to 4½ percent, it will also control infestations of oyster-shell scale, bud moth, and scurfy scale.

The different brands of tar-distillate emulsions vary considerably in composition. Tar-distillate emulsions should be applied in the spring before the buds show green at the tip and should not be used on trees that are winter-injured.

For San José scale and red-mite eggs, a 3-percent lubricating-oil emulsion may be used. Under certain conditions the oil emulsion may be combined with a tar-distillate emulsion.

For severe infestations of the fruit-tree leaf-roller, lubricating-oil emulsion diluted to contain from 5 to 6 percent of actual oil in the spray may be applied. Scurfy scale is held in check by the 6-percent concentration. The treatment is made after the buds have begun to swell but before they show green at the tip.

DN oil has been used successfully for several years in the control of certain pests. The suggested recommendations are 2 gallons of DN oil to 100 gallons of water for rosy aphis, San José scale, and scurfy scale, and from 2½ to 3 gallons for bud moth and oyster-shell scale. The material is applied in the spring before the buds show any green.

Green-Tip Spray. The green-tip spray is suggested in large orchards where it has been difficult to cover the entire orchard for aphis control in the limited time permitted at the regular delayed-dormant stage. While nicotine sulfate and lime-sulfur 1–50 usually proves more satisfactory at the delayed-dormant stage than at other times, it has been found possible to obtain commercial control with nicotine and a 3-percent lubricating-oil emulsion when the buds are showing green tips and the aphis eggs are not yet hatched. At this time the eggs are susceptible to the effect of nicotine sulfate in combination with lubricating-oil emulsion as given in the following formula:

Bordeaux mixture *	2–4–100
Lubricating oil	3 gallons
Nicotine sulfate †	1 pint
Water to make	100 gallons

* The Bordeaux is used to emulsify the oil and will also aid in preventing early apple-scab infection. If scab is not a problem, ½ pound of lignin-pitch may be used instead of the Bordeaux mixture to emulsify the oil.

† The nicotine may be omitted if tar distillate emulsion or DN oil has been used in the dormant spray or on non-aphis-susceptible varieties, such as McIntosh, unless bud moth is a problem.

San José scale, bud moth, and European red mite are also held in check by this application.

Delayed-Dormant Spray (when the leaves of the blossom buds are out from ¼ to ½ inch)

Lime-sulfur	2 gallons
Lead arsenate	3 pounds
Nicotine sulfate	1 pint
Water to make	100 gallons

Three pounds of hydrated lime included in the spray mixture tends to reduce the danger from arsenical injury.

The addition of ½ pound of lignin-pitch improves the spreading qualities of the spray mixture.

Lime-sulfur is included for the control of apple scab.

Lead arsenate is used for the control of case-bearers, the tent caterpillar, and other chewing insects. It is of value also in the control of apple scab.

Nicotine sulfate is used primarily against the rosy and green aphids and the bud-moth larvae. If the trees have been sprayed previously at the dormant or green-tip stage for these pests, the nicotine may be omitted in the delayed-dormant application. The nicotine may also be omitted on non-aphis-susceptible varieties, such as McIntosh, unless bud moth is a problem.

For the nicotine spray to be most effective against the rosy aphis, it is necessary to delay spraying until nearly all the eggs have hatched. Under normal weather conditions this has taken place by the time the opening leaves have reached the stage indicated, and that is usually early enough for scab control. In exceptional seasons, however, apple-scab infection may occur before the aphis eggs have hatched. Under such circumstances Bordeaux mixture in the green-tip application, or an additional early application of 2 gallons of lime-sulfur, may be required for scab control before the delayed-dormant spray.

Some growers prefer to apply the oil spray at the delayed-dormant stage instead of the dormant or green-tip stage for the control of scale and red mite. The spray should be completed before the leaves roll back and expose the blossom buds, to avoid the danger of russeting the fruit.

Pre-Blossom Sprays

Lime-sulfur	2 gallons
Lead arsenate	3 pounds
Water to make	100 gallons

The same suggestions relative to lime and lignin-pitch as those mentioned under the delayed-dormant spray are followed.

It is advisable to increase the lead arsenate and lime to 6 pounds each if leaf-roller is a serious problem.

If dust is used, a 90–10 sulfur–lead-arsenate mixture is indicated. If conditions are favorable for severe scab infection, the grower should spray as much as possible, using dust to complete the operation on time.

The pre-blossom spray or sprays, applied between the delayed-dormant spray and the bloom, are timed primarily for scab control. The points to be considered in timing the applications are: the occurrence of rain periods; the amount of new growth; and the stage of development of the scab fungus. In some seasons two pre-blossom applications may be required for effective scab control, especially on extremely susceptible varieties such as McIntosh.

Calyx-Spray (when the last of the petals are falling)

Lime-sulfur	2 gallons
Lead arsenate	3 pounds
Nicotine sulfate	1 pint
Water to make	100 gallons

The same suggestions relative to lime and lignin-pitch as those mentioned under the delayed-dormant spray are followed.

If red bugs are not present, nicotine sulfate should be omitted.

It is advisable to increase the lead arsenate and lime to 6 pounds each if leaf-roller is a serious problem.

If wet weather prevails during bloom and if scab control is doubtful, or if scab spots are present on the leaves, lime-sulfur is preferred. With dry weather during bloom and no scab present, wettable sulfurs may be used to reduce the danger of spray injury.

The calyx spray is applied chiefly to control apple scab and to poison the codling-moth larvae which later enter the blossom end of the fruit.

In orchards where the plum curculio is a problem, this application also affords early protection against this pest.

If dust is used a 90–10 sulfur–lead-arsenate mixture is indicated. If conditions are favorable for a heavy infection of scab, the grower should spray as much as possible, using dust as a supplementary measure. If red bugs are to be controlled, a separate application of a 2-percent nicotine-lime dust is indicated.

Curculio Spray (seven to ten days after the calyx spray)

Lime-sulfur	2 gallons
Lead arsenate	3 pounds
Water to make	100 gallons

The same suggestions relative to lime and lignin-pitch as those mentioned under the delayed-dormant spray are followed.

This spray is timed primarily for the control of the plum curculio, but it is also very important for the control of apple scab. Protection will also be afforded against rose leaf-beetle or rose chafer in orchards where these pests are a problem. The same considerations exist as in the calyx application with respect to the substitution of wettable sulfurs for liquid lime-sulfur in this application.

If dust is used, a 90–10 sulfur–lead-arsenate mixture is indicated.

Summer Sprays. The purpose of the summer sprays is to control codling moth, apple maggot, and apple scab.

It is the usual practice to include a fungicide in all the summer sprays for scab control. If a lime-sulfur schedule has been used through the primary infection and practically all early infections have been prevented, it is advisable to use one of the wettable sulfurs as a fungicide in the summer applications to reduce the danger of injury to foliage and fruit. In seasons when scab is not a problem, the fungicide may be omitted from some of the summer sprays during or preceding hot periods. However, a fungicide should be included in the last summer application unless a thorough examination of the trees, especially in the tops, shows that the scab is not a problem.

In planning a spraying schedule for the summer applications—that is, after the calyx or the curculio spray—it must be kept in mind that the regulations of the Federal Food and Drug Administration do not permit more than 0.01 grain of arsenic trioxide or more than 0.025 grain of lead per pound of fruit. A tolerance of 0.02 grain of fluorine per pound of fruit is allowed. These requirements may be met either by removing the residue by washing, or by modifying the schedule to keep the residue below tolerance. Washing is an additional expense; a modification of the schedule to keep the residue below tolerance may result in loss from codling-moth and apple-maggot infestation. If the grower is in a position to have his crop washed, he can follow a schedule designed to give adequate protection against these pests. It is at present impossible to suggest an entirely satisfactory schedule for those who cannot wash their fruit. The later sprays may be omitted, the strength of the insecticide reduced, or the materials less likely to leave excessive residues may be substituted for those ordinarily used, but these modifications will not invariably insure freedom from excessive residue.

The experience of growers and investigators over a period of years indicates that in most orchards representative of Hudson Valley conditions a spray schedule may be designed which offers possibilities of obtaining a maximum of protection against insect pests without running into difficulties from excessive spray residues. This program, referred to as a *non-washing schedule,* involves the substitution of calcium arsenate or basic zinc arsenate for the lead arsenate ordinarily used. A program to be followed where the fruit may be washed if necessary is referred to as a *washing schedule.* Both these schedules are given in the following paragraphs:

Non-Washing Schedule

(*where an effort is being made to avoid washing the fruit*)

First Codling-Moth Cover-Spray (about June 10 to 15)

Wettable sulfur (at manufacturer's directions)

or

Lime-sulfur (if scab is a problem)	2 gallons
Lead arsenate	3 pounds
Water to make	100 gallons

The same suggestions relative to lime and lignin-pitch as those mentioned under delayed-dormant spray are followed. Where arsenical injury has been severe in the past, 2 pounds lime to each pound of lead arsenate is suggested.

If home-made wettable sulfur is being used, ¼ pound of skim milk powder or 1 pound of soybean flour may be included in the spray mixture as a spreader.

This application will also afford protection against rose leaf-beetle or rose chafer in orchards where these pests are a problem.

If dust is used, a 90–10 sulfur-lead-arsenate mixture is indicated.

First Apple-Maggot Spray, or Second Codling-Moth Spray (about June 25 to July 1)

1. Formula for varieties ripening later than McIntosh and Cortland.

Wettable sulfur (at manufacturer's directions)	
or	
Lime-sulfur (if scab is a problem)	2 gallons
Lead arsenate	3 pounds
Water to make	100 gallons

For a spreader at this time, ¼ pound of skim milk powder or 1 pound of soybean flour may be used with lime-sulfur or in home-made wettable sulfur. If dust is used for this application, a 90–10 sulfur–lead-arsenate mixture is suggested. One pound of lime is used with each pound of lead arsenate. Where arsenical injury has been severe in the past, 2 pounds lime to each pound of lead arsenate is suggested.

2. Formula for McIntosh, Cortland, and other early varieties.

Wettable sulfur (at manufacturer's directions)	
or	
Lime-sulfur (if scab is a problem)	2 gallons
Calcium arsenate*	3 pounds
Hydrated lime	9 pounds
Water to make	100 gallons

The same suggestions relative to spreader as those mentioned in the first codling-moth cover spray are followed. If dust is used, a 90–10 sulfur–lead-arsenate mixture is indicated.

* Basic zinc arsenate, 3 pounds, may be substituted for calcium arsenate. One pound of lime is used with each pound of zinc arsenate.

Second Apple-Maggot Spray, or Third Codling-Moth Cover Spray (about July 15).

To prevent excessive spray residues, the use of calcium arsenate or basic zinc arsenate is suggested at this time on all varieties as follows:

Wettable sulfur (at manufacturer's directions)	
Calcium arsenate*	2 pounds
Hydrated lime	6 pounds
Water to make	100 gallons

The same suggestions relative to spreader as those mentioned in first codling-moth cover spray are followed. If dust is used, a 90–10 sulfur–lead-arsenate mixture is indicated.

Washing Schedule

(where fruit may be washed if necessary)

The following formula may be used in all three of the cover sprays outlined in the non-washing schedule.

Wettable sulfur (at manufacturer's directions)	
or	
Lime-sulfur (if scab is a problem)	2 gallons
Lead arsenate	3 pounds
Water to make	100 gallons

For a spreader, ½ pound of lignin-pitch may be used with lime-sulfur or in home-made wettable sulfur for the first cover spray, and ¼ pound of skim milk powder or 1 pound of soybean flour in the second and third cover sprays. One pound of lime is used with each pound of lead arsenate, or 2 pounds of lime with each pound of lead arsenate if arsenical injury is a problem.

If dust is used, a 90–10 sulfur–lead-arsenate mixture is indicated. The same precautions concerning residue should be taken in dusting as in spraying. During prolonged rain periods, it is advisable to make dust applications at shorter intervals than are indicated for spray mixtures. When there is already some scab on the foliage, control is made more effective by relying on applications of liquid lime-sulfur spray, since thorough applications of the material will burn out the scab lesions and will prevent in large measure the formation and spread

* Basic zinc arsenate, 2 pounds may be substituted for calcium arsenate. One pound of lime is used with each pound of zinc arsenate.

of summer spores. However, the danger from heavy applications of liquid lime-sulfur during the summer should not be overlooked.

Sprays for the Second Brood of Codling Moth

In most Hudson Valley orchards treatments for the second brood of codling moth have not been necessary in past years. In a few orchards, where codling moth has become a problem, protection from the second brood may be necessary in some years. For this, one or two applications of a fixed-nicotine compound may be used in August. Three quarts of summer oil plus ½ pint of nicotine may be used instead of the fixed nicotine.

(*New Jersey Exp. Sta.*)

Fig. 102. Peach: left, too early to spray for curculio; center, the proper stage; right, too late.

4. Selecting Machinery and Equipment for Making Applications. After the grower has studied carefully his insect and disease problems and has worked out his spraying program, he must then determine the machinery and equipment he will use in carrying the program into effect. It must be adequate for the purpose, and it should not represent an investment of money beyond the point necessary to accomplish the purpose.

Many kinds and types of machinery and equipment are available. In considering them the grower should take into

UNIVERSITY OF MARYLAND—EXTENSION SERVICE—COLLEGE PARK, MARYLAND

Peach Spray Calendar for 1939

Time of Application	Pests to Control	Material to Use in Making 100 Gallons Finished Spray	Remarks
1. *Dormant spray.* Before the buds begin to swell. Any time during dormant season when temperature is above 40° F.	Peach leaf curl, San José scale, European red mite, and terrapin scale.	(1) Concentrated liquid lime-sulfur (32 Baumé) 12 gal. and water to make 100 gal. of spray. *or* (2) 6-6-100 Bordeaux plus oil to make a 3% oil content spray. See Note 1.	If there is no scale present the lime-sulfur can be cut down to 1-15 (6¾ gal. concentrated liquid lime-sulfur and water to make 100 gal.) and the oil can be left out of the Bordeaux. If terrapin scale is present the oil content of the Bordeaux should be increased to 4%.
Pink spray—Growers having had serious blossom-blight the past season should apply a spray when pink shows in the buds. Use a wettable sulfur.			
2. *Petal-fall spray.* When all the petals have fallen.	Curculio and brown rot.	(1) Zinc sulfate (crystal form) 3 lb.; hydrated lime 8 lb.; lead arsenate 2 lb.; water to make 100 gal. *or* (2) Zinc sulfate (monohydrated form) 2 lb.; hydrated lime 8 lb.; lead arsenate 2 lb.; water to make 100 gal. See Note 2.	In orchards where brown rot has been serious, or where blossom blight was serious, it would be advisable to add a fungicide of dry-mix sulfur-lime or a wettable sulfur. Use wettable sulfur at the strength recommended by the manufacturer.
3. *Shuck spray.* When the shucks break and the small peach is half exposed.	Curculio and brown rot.	Same as petal-fall spray except *add dry-mix sulfur-lime, or a wettable sulfur.*	Make two applications to the outside rows of trees as the curculio attacks these trees first.
4. *First cover spray.* Two weeks after the shuck spray.	Curculio, Oriental fruit moth, brown rot, and scab.	Same as the shuck spray.	This is the *last* spray in which lead arsenate will be used. Spray the trees thoroughly.
5. *Second cover spray.* From two to three weeks after the first cover spray.	Curculio, Oriental fruit moth, scab, and brown rot.	Same as the first cover spray except leave out the lead arsenate. See Note 3.	*Use no lead arsenate in this spray.*
6. *Third cover spray.* Two weeks before harvest.	Oriental fruit moth, scab, and brown rot.	Same as second cover spray. See Note 3.	If it is more convenient at this time to dust, one of the following formulas may be used: 80-20, 85-15 or 90-10. The first figure is sulfur and the last figure is lime, in pounds per 100 lb. of the mixture.

Peach: Note 1—Tank-Mix Oil Emulsion. Steps in making oil emulsion by the tank-mix method.

(1) Fill the tank about ½ full of water. (2) Start the agitator and add the correct amount of emulsifier (in Bordeaux-oil the Bordeaux acts as the emulsifier). (3) Pour in the required amount of oil. (4) Pump the mixture through the nozzle back into the tank until it is emulsified. (5) Fill the tank with water and use at once.

Peach: Note 2—Zinc lime mixture has been found to be effective in reducing arsenical injury on peaches. It should be prepared in the tank as follows: Fill the tank ½ full of water and start the agitator. Add the zinc sulfate slowly and after it has dissolved, make a paste of the lime and wash it through the strainer. Next add the sulfur fungicide, and *last*, the arsenate of lead. This spray should be used at once.

Peach: Note 3—If the season is favorable for brown rot development, it will be advisable to put on some additional sulfur sprays or dusts. The grower should examine the orchard and, if any signs of brown rot are found, he should put on a sulfur spray or dust at once.

account definite facts about his fruit enterprise which he himself knows, and equally definite information from authoritative sources, concerning machinery and equipment.

Procedure:

(*a*) Consider the size of the fruit enterprise.
(*b*) Consider the length of time within which applications must be made and the number required.
(*c*) Consider nature of ground over which work must be done.
(*d*) Consider accessibility of the water supply.
(*e*) Consider availability of labor.
(*f*) Consider comparative merits of spraying and dusting.
(*g*) Consider important mechanical features of sprayers and equipment.
(*h*) Consider important mechanical features of dusters and equipment.
(*i*) Consider advisability of stationary spray plant.
(*j*) Select machinery and equipment.

(*a*) *Consider the Size of the Fruit Enterprise.* This refers both to the acreage or the number of trees, and to the size of the trees. A machine of a given capacity can do only a certain amount of work even when operating at maximum efficiency and under the best of conditions. Number of trees is a more dependable factor than number of acres, since it is the trees that must be sprayed rather than the ground. However, acreage and distance between trees may be important from the standpoint of the hauling necessary in order to put the machine into action.

A power sprayer capable of carrying one gun at full capacity should cover 150 to 225 well-grown trees about 20 years old in 10 hours. If all conditions are favorable, including availability of water, the upper figure is possible, but it will not be attained on the average. A two-gun outfit, if it is really such in capacity and power and not merely an outfit to which two guns have been attached, will cover almost double the number of trees except that time consumed in filling and haulage does not change. Small trees require less material and can be covered more quickly. However, more hauling and walking are required, and the increase in number sprayed is hardly proportionate to the decrease in their size.

Small trees may, of course, be cared for with lighter and less powerful equipment than is needed for large trees.

(*b*) *Consider the Length of Time within Which Applications Must Be Made and the Number Required.* The grower knows from his study of insects and diseases the stages in their life histories when they may be controlled. He knows that he must perform his spraying operations at these times, and that if he does not do so, the operations will result in failure.

For instance, he knows that, whereas he may control peach leaf curl by spraying at any time during the dormant season, he must spray for aphis when the insect is present and in an exposed situation on the buds. He must cover the orchard rapidly in a rainy season for scab control. An outfit that might be adequate to control peach leaf curl would not do at all for some of the organisms that must be controlled within narrow time limits during the growing season.

Again, one thorough application each year is sufficient for peach leaf curl and usually for scale. Three or four applications may be required for codling moth in regions where there are several broods each year, and an even larger number of applications may be required for apple scab. These facts influence the decision in selecting machinery.

Further allowance must be made for windy or rainy weather during the period when the organisms may be controlled. This cuts down the available time and makes it necessary to increase the capacity of the outfit. In most parts of the country, except the Far West, not more than four days out of each week are available for effective orchard applications. The number is often less.

(*c*) *Consider Nature of the Ground over Which Work Must Be Done.* It is evident that level or rolling lands, free from rocks, offer fewer obstacles to rapid work than rough or mountain lands. Lighter outfits of less capacity may be necessary on hilly land than on level land, and the work must consequently go more slowly.

(*d*) *Consider Accessibility of Water Supply.* Time spent in procuring water is time lost in covering the trees. The round trip to water one-fourth mile distant will require at least 15 minutes with a team, 8 to 10 minutes with a tractor, without regard to the time spent in filling the tank. Many orchards are so poorly located with reference to water supply that nearly one-half the spraying time is spent merely in getting the water. Growers operating under such conditions are under a serious handicap. They need to consider carefully the feasibility of applying most of their materials without water. If this does not seem practicable, then they may well expend a considerable sum to arrange a more accessible supply of water. The same outfit will then apply a much greater quantity of material in the same period, or the grower may reduce the equipment needed.

Together with the convenience of the water supply should go arrangements for mixing materials and filling the tank that will save time and increase the productive efficiency of the outfit.

(*e*) *Consider Availability of Labor.* This implies both quantity and quality. Much is involved in the spraying operation beside the mere application of materials. The machinery is quite complicated; formulas for mixings and dilution are exact; the time limits within which effective applications may be made are often narrow. The man on the spray outfit should visualize the organisms he seeks to control and the finished product he hopes to achieve. For these reasons, growers with small orchards attempt to handle the spraying job through some member of the family who is vitally interested. Large growers employ trusted men of more than average intelligence to supervise and direct the operation. If only a few capable men are available, then a number of high-class outfits of large capacity should be considered.

(*f*) *Consider Comparative Merits of Spraying and Dusting.* When materials are applied in water as a carrier, the operation is termed *spraying*; when they are applied in the dry state, with or without a carrier, the operation is termed *dusting*. Spraying is the standard practice in most fruit sections at the present time. In considering the purchase of machinery and equipment for insect and disease control, however, the grower will wish to take account of all the factors in the situation, including both present practices and probable developments in the immediate future. His investment in such machinery and equipment cannot be repeated each season. It is important, therefore, that he invest wisely, taking into account both general facts and his own special conditions and problems. Certain advantages in dusting are apparent.

1. The work may be done much more rapidly. Dusting 10 acres before breakfast or after supper is not at all out of the question. Thirty acres of mature apple orchard and 40 acres of peaches may be dusted in a 10-hour day with a modern outfit. This is nearly 5 times the average that can be covered in the same period with an equally modern sprayer. With a large acreage and a short period within which the application can be made for the greatest effectiveness, with the period frequently cut down by bad weather, and with the importance of reducing labor costs to a minimum, this factor assumes great importance.

2. The labor requirement is less. This relates both to the rapidity with which the work may be done and to the number of men required to do it. A large dusting outfit may be operated with one-third less man power than a large sprayer.

3. The water requirement is eliminated. No time is lost in hauling water or in filling the tank. Sufficient materials for a half-day's work may be carried on the machine, and supplies for the entire day may be quickly distributed at convenient points throughout the orchard.

4. The equipment is light. It may be used where the heavy liquid outfit cannot be taken, on soft ground and rough land. As a rule, a loaded duster weighs less than an empty sprayer.

5. Dust may be applied when the fruit and foliage are damp, whereas for spraying they should be dry. Time is thus saved in the morning while the dew is on, or at night after it has fallen, or between showers.

6. Standard dusting materials are less caustic and hence less likely to cause burning than standard spraying materials. This is of impor-

tance in those sections where burning frequently results from use of concentrated lime-sulfur or Bordeaux mixture. Dusted fruit in such sections often possesses a brighter finish than sprayed fruit.

7. The investment per acre or per number of trees is less with a duster than with a sprayer. A good dusting outfit with a small first cost will care for a quantity several times greater than an equally good sprayer. This materially reduces the overhead costs.

8. The removal of spray residues from fruit when applications late in the season have been necessary is becoming a problem of considerable importance. Dusting materials may on the whole be removed more easily from the fruit than the materials applied in liquid form.

9. For home fruit gardens, the small hand duster is much more convenient and usually less expensive than a small sprayer.

Other considerations not favorable to dusting at the present time are:

1. Materials for dusting are at present more expensive than for spraying. The difference is considerable and usually offsets the labor-saving factor in dusting.

2. Dusts to compare favorably in effectiveness with the spray materials for dormant applications have not yet been perfected. For instance, dusts are not effective against San José scale at the present time. Likewise, aphis, largely controlled during the early part of the growing season by nicotine sprays, cannot be controlled satisfactorily at present by nicotine or other dusts.

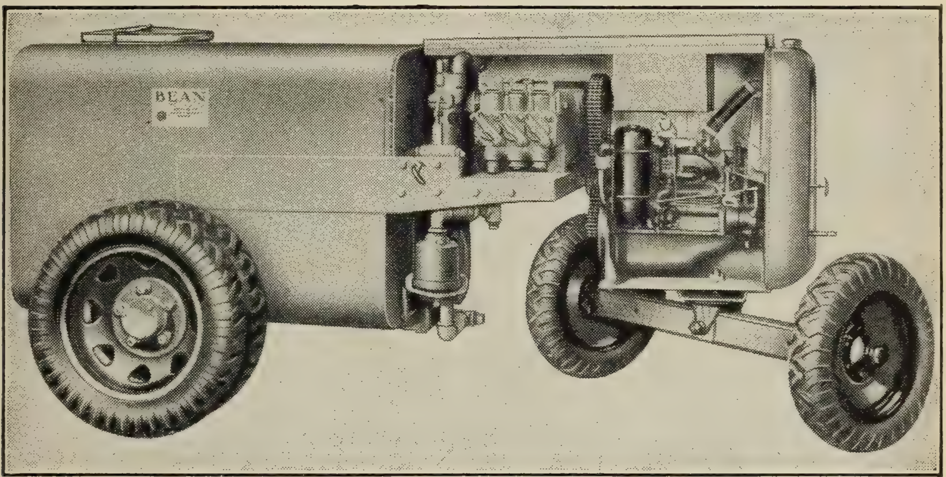
3. Authorities and growers in various sections disagree sharply concerning the effectiveness of dusts as compared with sprays, chiefly for apple scab. There is considerable agreement that apple insects, with the exception of the various scales and aphis, may be controlled effectively by dusts, during the growing season. There is quite general agreement that dusts are effective for the control of insects and diseases of the peach during normal growing seasons.

In New York, Massachusetts, Nova Scotia, Michigan, Pennsylvania, Minnesota, Virginia, and some other states, experiments favorable to dusting for summer applications have been reported. In New York and elsewhere, some large growers are relying upon dusts exclusively for scab control.

In some of these sections, as well as in Indiana, Connecticut, and New Jersey, other tests have given results in favor of spraying.

It should be kept in mind that fruit growers have been working with liquid sprays and accumulating experience concerning them for a long time. This is not to be lightly cast aside. However, when the same study and attention have been accorded the use of dusts, the results may bring about radical changes in control methods.

With the foregoing facts in mind and with a knowledge of the comparative results of dusting and spraying attained by both experimental agencies and growers in the section where

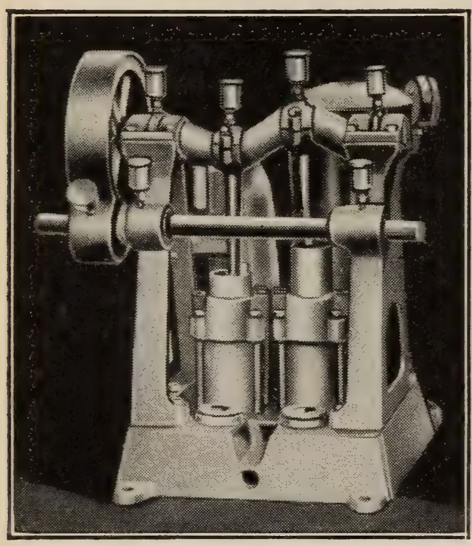


(*John Bean Mfg. Co.*)

Fig. 103. The usual method of assembly of a spray outfit, with engine at the rear, pump in center, and tank in front.

his fruit enterprise is located, the grower is ready to make his decision between the two methods of application. It is evident that, though the decision is in favor of spraying as the usual means of control and at present the exclusive means during the dormant season, the duster may still be highly desirable as a supplemental agency to cover the planting quickly when the time factor is all-important or when labor is scarce. Thus, although most growers own at least one good sprayer, using it for dormant and early foliage sprays, many of them also own a duster, using it extensively for the regular summer applications or holding it as an insurance and safety factor against the time of need.

(*g*) *Consider the Important Mechanical Features of Sprayers and Equipment.* Spray machines are known as *power, traction,* or *hand* machines, depending on the source of the power for their operation. The commercial grower is primarily interested in the power outfit, the term applied to engine-operated machines. Such outfits are well standardized, and many good ones are on the market. They provide a high pressure when desired, a uniform pressure throughout the spraying operation, and a capacity ranging from the small one-cylinder outfits to the giant-powered machines used for forest, street, and park spraying.

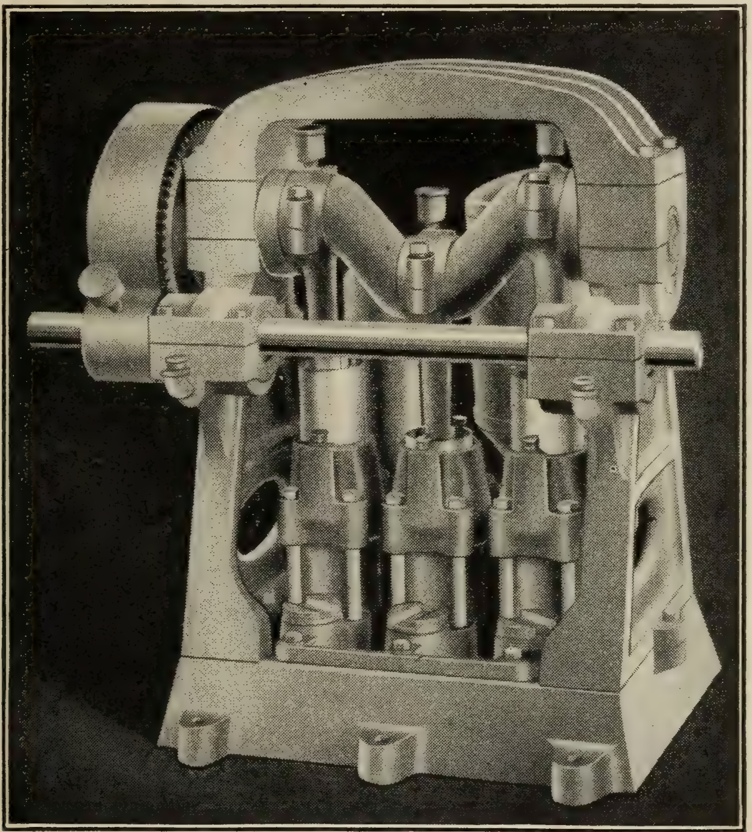


(*Hardie Mfg. Co.*)

FIG. 104. A two-cyclinder pump.

1. *The Pump.* The spray machine can be no better than its pump. Pump capacity is important. It should be great enough so that it may do the job expected of it with a reserve left over. A machine operated to the full limit of its capabilities is subjected to great strain and goes to pieces sooner than more powerful machines operating with an ample reserve. The capacity of a sprayer is the number of gallons per minute that the pump will deliver at a stated pressure, usually 600 pounds. Many manufacturers overrate the capacity of their machines under actual orchard conditions. Many growers, on the other hand, habitually run their pumps with an overload that materially reduces their period of service. Allowance must be made for the capacity losses due to worn valve seats and cylinder packing, small leaks, and other minor defects in opera-

tion, which cannot be remedied during the height of the spraying operation, but which nevertheless affect the productive capacity of the outfit. A 10-gallon per minute outfit is likely to become a 6- or 8-gallon outfit before the spraying is done and repairs may be made.



(Hardie Mfg. Co.)

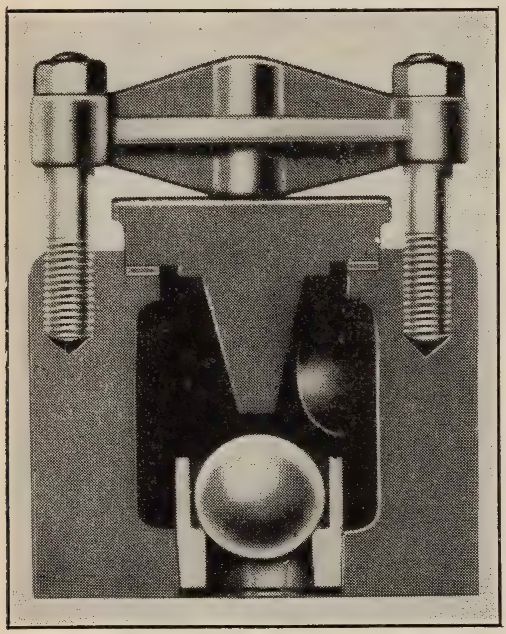
Fig. 105. A three-cylinder pump.

Power spray pumps have two, three, or four cylinders (Figs. 104 and 105). Values and efficiency cannot be measured solely in terms of the number of cylinders. A pump with three small cylinders and inadequate engine power may be inferior to a good two-cylinder outfit.

The smallest power outfits have pumps of two cylinders with a 2-inch bore and a 3-inch stroke. They are driven by 1- to

3-horsepower engines. Their capacity is from 6 to 10 gallons per minute. They will carry one lead of hose and rod with three nozzles maintaining a pressure of 400 pounds. This type of machine will care for upward of 5 to 10 acres of orchard, the determining factor being sufficient time to get the spray on during the period of effective control.

Three- and four-cylinder pumps deliver 15, 35, and as much as 50 gallons per minute. They are driven by 5- to 25-horsepower engines or by a power take-off from the tractor. Larger outfits will carry two lines of hose with 6 and 8 nozzles on each and still maintain a pressure of 600 and 700 pounds. The grower must decide whether he is to use one large outfit or more smaller ones.

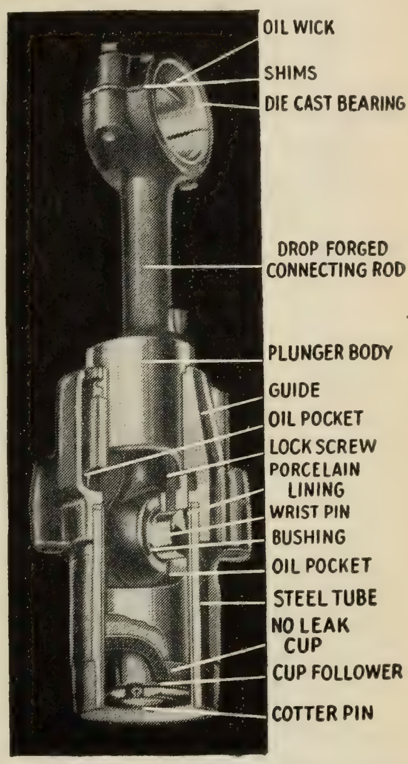


(*John Bean Mfg. Co.*)

FIG. 106. The ball valve gives long wear without leakage.

(*a*) *Pump Specifications.* The pump design should be simple with all parts easily accessible. Parts subject to wear should be so designed and located that they can be quickly replaced. Many spray materials are corrosive. Parts in contact with them are usually of porcelain or brass. Valves of the ball type, made of stainless steel, with seats that are quickly replaceable, give greatest satisfaction (Fig. 106). Poppet and disk valves do not wear as evenly as ball valves, and leakage becomes a serious problem with them.

Pump cylinders (Figs. 107 and 108), are of brass, porcelain, or steel, the steel ones being intended for quick and ready replacement. The plunger within the cylinder may be of an expanding type of material creating suction or pressure as it works back and forth, or the packing may be stationary at the end or top of the cylinder, fitting closely about the piston so as to prevent leakage. In the latter type a smooth metal plunger is used. In either case, the wear is intended to come on the soft, expanding material which is easily replaced, rather than on a hard metal part. Packing materials may be hemp, composition, candlewick, etc., treated with oil or graphite to soften them.



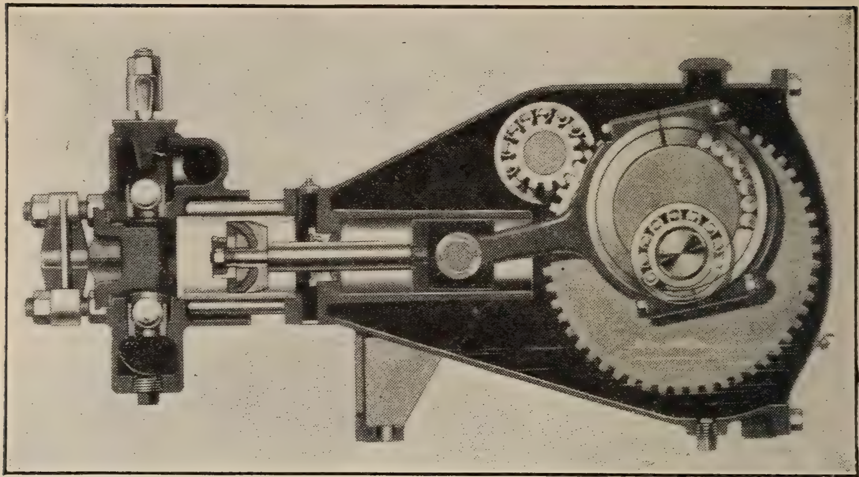
(*Hardie Mfg. Co.*)

FIG. 107. The detail of a pump cylinder.

The air or pressure chamber is an essential feature of the pump. The spray material enters the chamber under pressure; the air is compressed and aids in maintaining an even flow of the material to the nozzles. The size of the air chamber should increase with the size of the outfit. The pressure gage is mounted on the air chamber.

Uniform pressure is further insured by the pressure regulator (Figs. 110 and 111). In its best form it opens when a certain pressure has been reached, returning part of the spray material to the tank, and closes when the pressure falls below this point. Variation in pressure is thus taken up in the machine, and the flow of material at the point of application to the trees remain uniform.

The pump may be operated by chain, by belt, by yoke, or by gear. Gear-driven machines, rigidly mounted, are standard, though chain and yoke machines have also given



(*John Bean Mfg. Co.*)

FIG. 108. Another view of the interior of a pump cylinder and related parts.

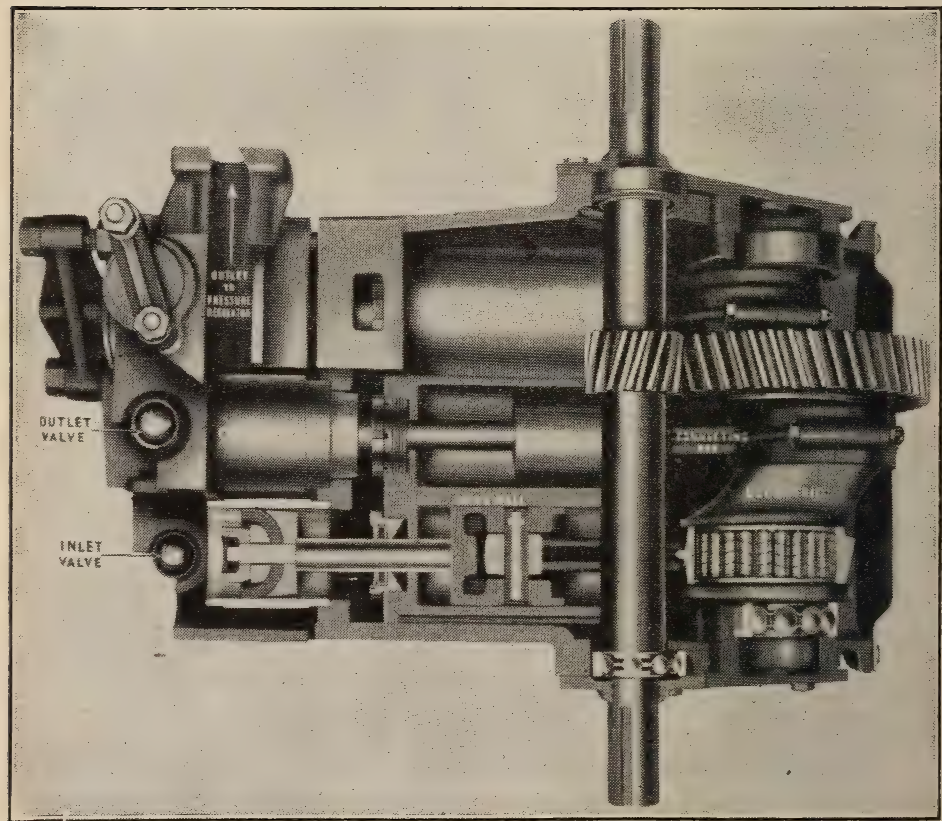
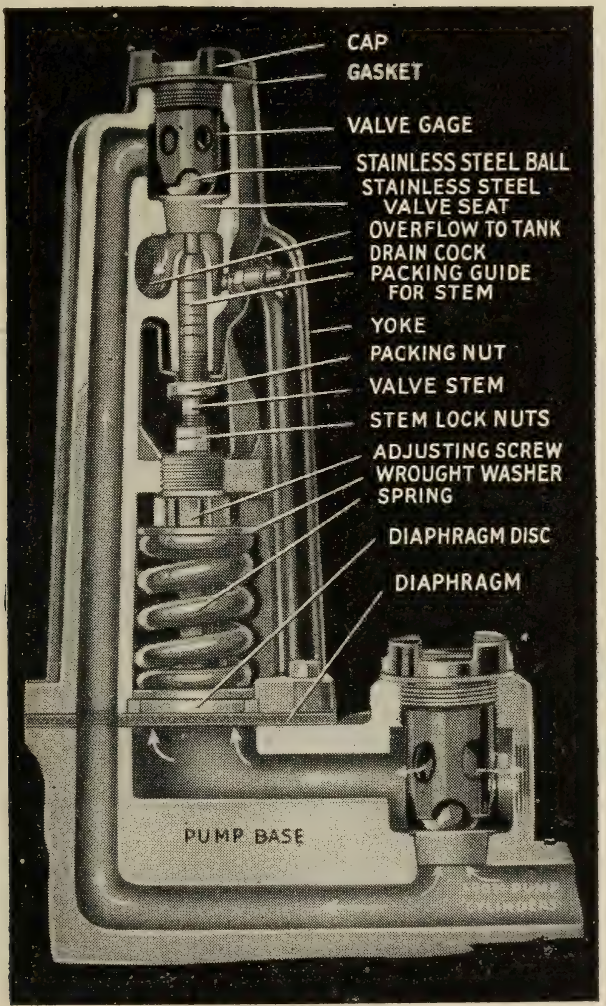


FIG. 109. The hook-up of the cylinders to the source of power.

satisfaction. Belts frequently slip, stretch, wear, or break. A belt-driven machine may, however, be stopped quickly in an emergency.

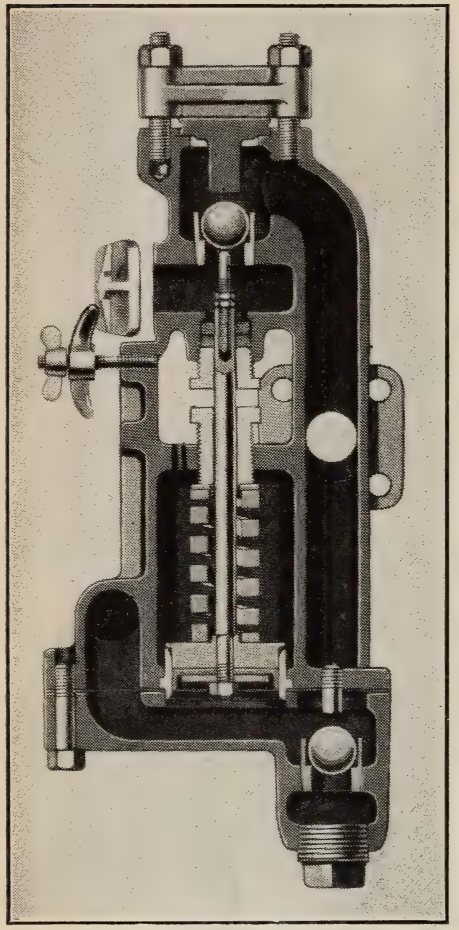


(*Hardie Mfg. Co.*)

Fig. 110. The parts of the pressure-regulator mechanism.

Pumps require thorough and continuous lubrication. Oil prevents the grinding and friction of metal parts and keeps the packing pliable. Oil cups should be readily accessible, and the oil feeds should be simple and direct.

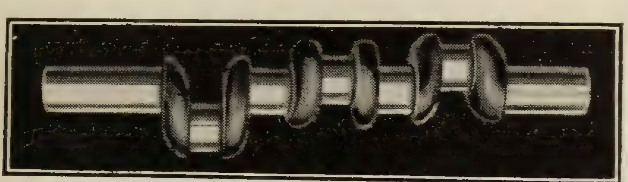
2. *The Engine.* Gasoline engines of the vertical type provide the power on most outfits. It is better to have an over-size engine running well within its resources than a smaller one extended constantly to its limit of performance. Seldom, if ever, should the engine be of less than 2 horsepower; one of 3 horsepower is necessary for an outfit of medium capacity. For duplex and triplex pumps, successively larger engines will be required as the capacity increases. Larger machines, delivering 15 gallons or upward per minute, require engines capable of developing 6 to 10 horsepower, and the largest machines develop up to 35 horsepower. The number of cylinders varies from one on the small outfits to four on the giant machines. A very good source of power and one very commonly used today is the power take-off from the tractor. This can drive pumps ranging in capacity from 15 gallons per minute up to the largest built (Fig. 113).



(*John Bean Mfg. Co.*)

FIG. 111. A true pressure regulator has two valves. When the pump is running, but no spraying is being done, the upper valve opens to take the load off pump and engine. A relief valve merely diverts excess material back to spray tank, but does not relieve engine and pump.

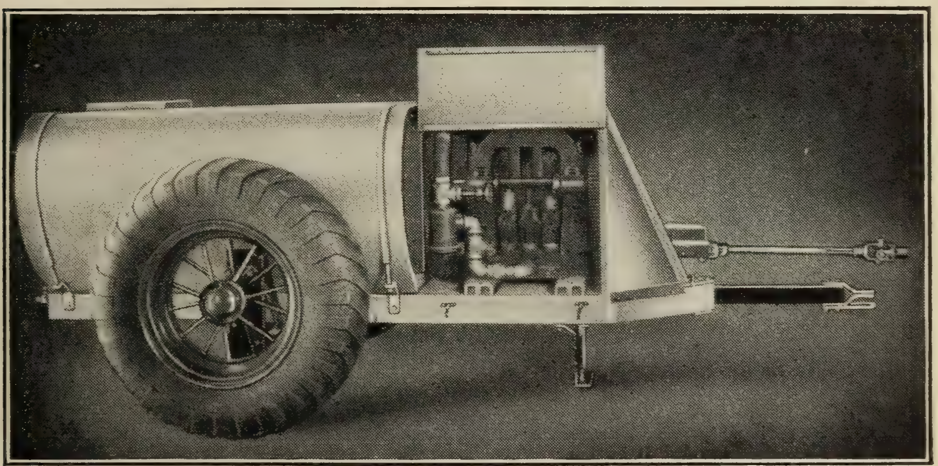
The engine must be hauled about the orchard. It should therefore be as light as is compatible with durable and reliable performance. Simplicity of operation, a minimum of parts, readily accessible parts, and ease of obtaining new parts are major factors, just as in case of the pump. Water-cooled engines with a circulatory water system are standard. Air-



(*Hardie Mfg. Co.*)

Fig. 112. The crankshaft transmits power to the pump. It should have plenty of reserve strength.

cooled engines are used by some manufacturers. Magneto ignition systems are standard equipment on the newer machines; they do not become deranged as easily as the older battery systems, but it is well to have a battery system on



(*Hardie Mfg. Co.*)

Fig. 113. A trailer outfit operating by means of a power take-off from the tractor.

hand to use in case of emergency, since the magneto system when deranged may require the attention of an expert.

A governor to control the engine speed as the load varies is very desirable and makes it unnecessary to watch the engine closely during the spraying operation.

A carburetor adjustable at a single point, the needle valve controlling the gasoline flow, is desirable. When the point where combustion is best has been located, it should be marked and changes made only as the temperature varies or as the engine through prolonged use varies in the internal relationships of its parts.

The oiling system should be thorough but simple, requiring a minimum number of operations to care for it.

Engines are mounted either in front or rear. On a team-handled outfit, especially if the horses are uneasy, a front-mounted engine is inconvenient to start. Turn the front trucks at right angles so that the engine is more accessible. On the other hand, the heavy load of material when the tank is full moves more easily over the rear axle than over the front, which should turn freely. In a few outfits engines are mounted on top of the tank, but they are relatively inaccessible, in the way of branches, and on the whole inconvenient.

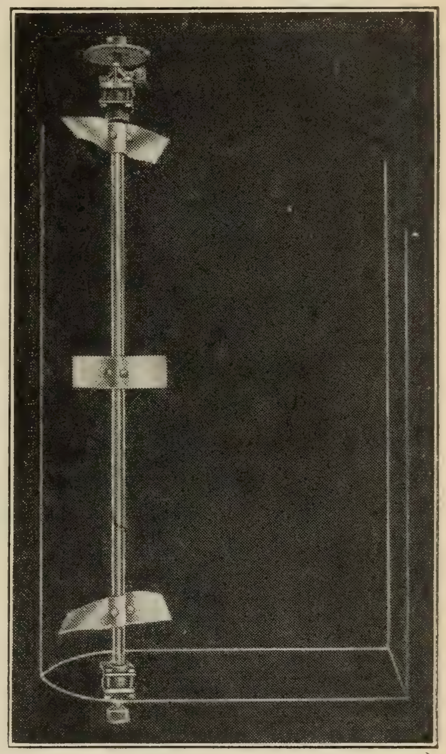
3. *The Tank.* Either wooden or steel tanks are used on all standard makes of sprayers. The best Western cypress or fir is not affected by corrosives used in spray mixtures, and for many years they have been very satisfactory woods for the manufacture of good spray tanks. Steel tanks are also strong and tight. They may be made in almost any shape and may be electrically welded and treated to give special corrosion-resisting qualities. Wooden stave tanks of a U-shape permit the withdrawal of all the material from the corners.

The tank may be mounted above the axles on bed pieces, or underslung with the rear axle passing through the tank. On hillsides, where it is important to have the center of gravity as low as possible to reduce the danger of overturning, the underslung tank, though more expensive, is preferable.

Tank capacity will vary with the topography of the ground and with the power available to haul the sprayer. The large tank requires few trips to the filling points and is a time saver.

Tanks holding 200 gallons are common, though larger ones are gaining in popularity. The choice depends on the conditions. A 100-gallon tank may be as large as can be handled under certain conditions.

4. *The Agitator.* Many spray materials are in suspension rather than in solution. Emulsions have a tendency to separate into their component parts; two or more solutions may not mix freely when put together. For these reasons an effective system of agitation of the spray materials in the spray tank is of great importance. Agitation may be secured by means of propellers attached to a shaft running the length of the tank near the bottom and connected to the pump (Fig. 114). The number of revolutions necessary per minute will depend on the size of the propellers, but should be from 50 to 60 for large ones and a higher number for small ones.



(*Hardie Mfg. Co.*)

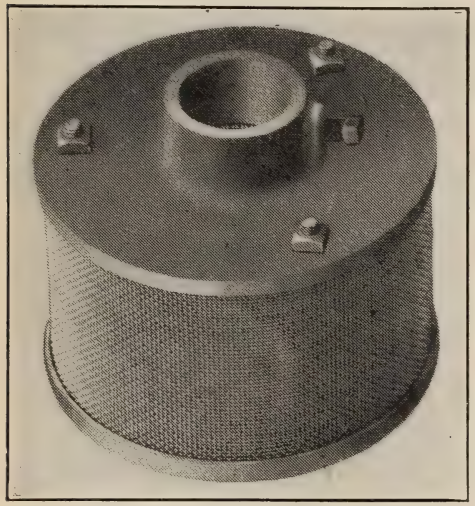
Fig. 114. The agitator operates near the bottom of the tank. Its speed may be changed by altering the size of the sprocket at the left.

Paddles which sweep the entire length of the tank close to the bottom to prevent sediment from accumulating are also used.

5. *Transfer of Material from Tank to Pump.* The transfer may be by suction or by gravity. Suction feed gives less danger of clogging and does not carry over heavy or coarse sediment to the pump. A gravity feed is satisfactory for materials containing no sediment, but if sediment is present and the machine goes out of action even for a short period the

connecting pipe may clog. Since both materials carrying sediment in suspension and those which do not enter into the normal spraying program, the suction type of feed is preferable.

6. *The Truck.* A truck with a heavy steel frame rigidly bolted or riveted is best. Rocking bolsters compensate for unevenness in the ground, keep the load in proper position, under the frame are desirable for close quarters and sharp turns, as in closely planted orchards. Wide tires are best on sandy or soft ground. The heavier machines are equipped with tires 5 to 8 inches wide. On the other hand, on steep, hard ground, narrow tires will cut in more and give better footing than wide tires.



(*Hardie Mfg. Co.*)

FIG. 115. The suction strainer in the tank should be of heavy brass mesh, and readily accessible for cleaning.

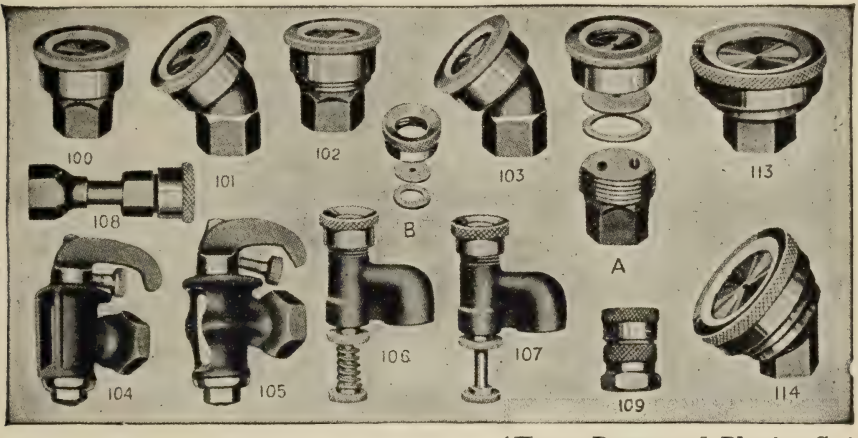
Pneumatic tires are being used on many trucks. There seems no doubt that the life of equipment mounted on rubber is longer. The ease of handling and all-round general efficiency make it seem likely that before very long rubber mounting will be standard equipment.

7. *The Tower.* A tower mounted on the tank is desirable for spraying tall trees. With the advent of the spray gun and the practice of heading trees lower than formerly, the tower is not so necessary as in the past. However, in many places the efficiency of the spraying job would be increased by its use. Where trees are 20 feet or more in height, the tower should be considered standard equipment.

8. *Nozzles.* Nozzles are of two general types. The Bordeaux nozzles exemplifies the first, giving a flat, fan-shaped

spray. In the second type, the spray emerges from the nozzle in the form of a cone. The various disk nozzles and the vermorel nozzle belong to this classification. Differences in form of spray in these two types are obtained by differences in details of construction of the nozzles. The spray gun shoots a cone-shaped spray, unless opened wide, when the spray resembles that from the Bordeaux nozzle.

The Bordeaux nozzle gives a direct, driving spray which can be applied even in the face of a strong wind. The particles



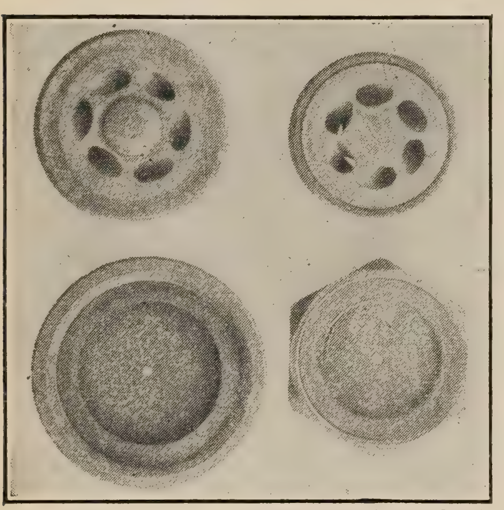
(*Hayes Pump and Planter Co.*)

FIG. 116. Spray nozzles and accessories taken from a manufacturers' catalog.

100, 102, 109, 113, Disk nozzles.
101, 103, 114, Disk angle nozzles.
104, 105, Bordeaux nozzles.
106, 107, 108, Vermorel nozzles.
A. Disk nozzle parts.
B. Nozzle cap parts.

of spray are not so fine as in the disk nozzle, fineness being a desirable attribute for most purposes. Less surface can be covered in the same time with the Bordeaux nozzle than with the disk nozzles, and its construction causes it to catch more readily in the branches.

Disk nozzles of standard make, designed for the pressure that the outfit will carry, are desirable. As the hole in the disk wears larger, the greater is the quantity of spray that will feed through in a given time, and the more the pressure will be reduced. Growers often make the mistake of not replacing these disks frequently. A fine driving spray that spreads into a cone as it comes from the nozzle and goes on to the fruit and foliage in small globules, rather than one that washes the tree, is the objective. The Virginia Experiment Station found that, at 300 pounds pressure and using arsenate of lead, outer spray disk openings of $\frac{1}{16}$ and $\frac{1}{12}$ inch wore in about 45 hours of continuous spraying to $\frac{1}{12}$ and $\frac{1}{10}$ inch, respectively. It would seem then that the outer disks should be changed after one week of use.

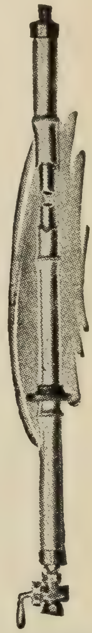


(*Virginia Exp. Sta.*)

FIG. 117. Nozzles with six holes in the disk are favored by some growers. At the left the whirl disk and nozzle base are in one piece; at the right the whirl disk is removable from the nozzle base.

The shape of the spray is determined in the eddy chamber, the space between the inner and outer disks, created by the insertion of a washer or gasket from $\frac{1}{8}$ to $\frac{3}{16}$ inch thick The outer disk has a single opening in center. The inner disk, usually much thicker, has from two to six holes driven through at an angle, near the outer circumference. The deeper the eddy chamber and the straighter the holes in the inner disk, the narrower the cone of spray and the greater its driving quality. The spray of greatest fineness is obtained by a shallow eddy chamber, a decided slant to the holes through the inner disk, and a small aperture in the outer disk, but its driving or carrying power is reduced. Nozzles with six holes in the inner disk, and with a spray apperture of $\frac{1}{16}$ to $\frac{1}{12}$ inch, have proved very satisfactory and throw the spray much farther than nozzles with but two holes in the disk.

Disk nozzles have capacities ranging from $\frac{3}{4}$ to $2\frac{1}{2}$ gallons per minute at 250 pounds pressure, depending upon the construction details already mentioned. They are frequently arranged in pairs or in clusters of three or even more. When the nozzles are so arranged, the cone of spray is narrowed and the driving power is increased as the nozzles are brought closer to each other, the air resistance being decreased. At least one experiment station recommends a set of disk nozzles on a spray rod, 8 to 10 feet long, in preference to the spray gun.



(*Hayes Pump and Planter Co.*)

FIG. 118. Bamboo spray rod with aluminum core.

When rather coarse materials in suspension must pass through the nozzle, the larger sizes of disk apertures should be used. Angle disk nozzles are helpful in reaching the under surfaces of the leaves and in giving better direction to the spray, and they enable the operator to keep out of the spray himself. They constitute standard equipment.

9. *The Gun.* The spray gun is a disk nozzle or multiple nozzle of large capacity with a range that may be changed at will. In effect, it is a nozzle with an adjustable eddy chamber in the form of a plunger. The gun may be entirely shut off by turning the plunger up against the exterior disk. As the plunger is withdrawn and the eddy chamber increases in depth, the cone of

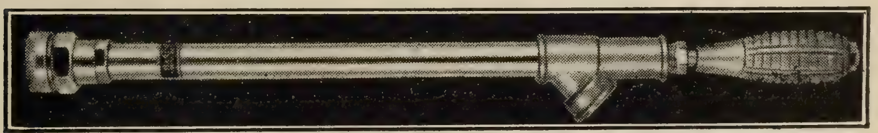
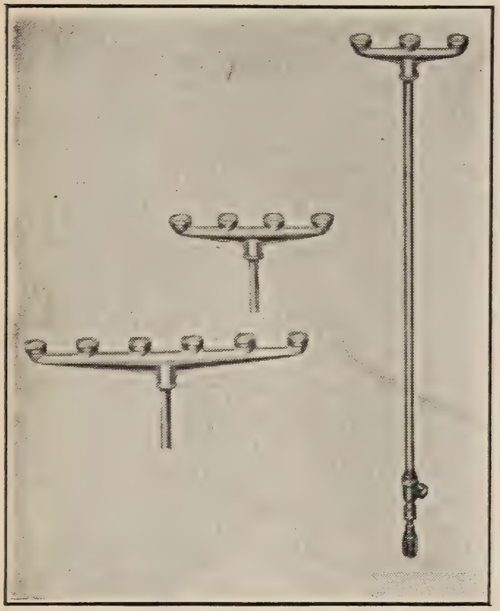


FIG. 119. A powerful one-nozzle spray-gun of modern design.

spray becomes narrower, with coarser particles and greater driving range.

The range and type of spray may be changed by a partial turn of the hand: foliage near at hand may be coated with a fine mist; that at a distance may be reached by a driving spray. The gun is light and easy to carry and handle, being usually from 18 to 36 inches long and weighing from 3 to 4 pounds. It is commonly constructed of brass, but aluminum guns with brass nozzles and brass movable parts are now available. They are both light and durable. (Figs. 119 and 120.)



(*John Bean Mfg. Co.*)

FIG. 120. Spray guns with a battery of nozzles.

The spray gun has largely replaced the rod and nozzle on power outfits. It makes possible the application of large quantities of material in a short period. A pressure of 400 pounds or more is usually needed. The spray gun saves time, applying 3 to 6 gallons per minute, or a larger quantity with a double gun. It appreciably reduces the labor cost of application. It may not save material—that depends on the agility of the operator.

Much poor work has been done with the spray gun, largely because too much was expected of it. Some growers have returned to the rod and nozzle. The temptation is great merely to stand on the ground or spray tank, turn on the pressure, shoot a driving spray at the tree, and assume that the job is done. It is true that the force of the spray will turn many of the leaves as it strikes them, thereby coating the lower leaf surfaces, but this will be true of only a fraction of the leaves. The gun does not eliminate the necessity of spraying from the ground, and where the trees are headed low, it is difficult to coat the lower leaf surfaces thoroughly with this device.

At low pressures the gun of the usual type will give poor results, and many growers have made a mistake in attempting to use two guns on an outfit that could carry but one. The usual type of sprayer of 3½ to 4 horsepower will not carry two guns of the present types and do a uniformly good job of spraying. This is because the guns, when operating fully, require more material than the pump can deliver. Studies indicate that under such conditions the guns will take 4 to 5 gallons each per minute while the rated capacity of the pump is only 8 to 10 gallons per minute, in practice often falling below this.

Table 41 gives the results of actual orchard tests made by the Virginia Agricultural Experiment Station* with various types of equipment at different pressures. The nozzles listed were arranged in sets of three or four. Note (*a*) that ⅛-inch spray disk openings are too large to give satisfactory results at any pressure used, and (*b*) that the nozzles arranged in a straight line gave as great a delivery of material and fully as great a drive of material as the guns.

Modifications of the spray gun under different names are now available, claiming greater perfection in adjustment and manipulation.

10. *Spray Rod.* Some growers still prefer the spray rod (Fig. 118). One or more nozzles are mounted at the end. Both bamboo and iron rods are in use, but the former is much lighter, of greater diameter, and easier to hold. It is hard work to manipulate a spray rod all day, so that these factors are of considerable importance.

An aluminum or brass core extends through the rod, carrying the spray material to the nozzle. The fittings holding the rod in place must be kept tight or the rod will turn in the hands independent of the core. Cracks or checks in the rod should be wound with tape as soon as they appear. A collar of metal or rubber at the upper end serves as a shield or guard to prevent the drip from working back along the rod to the

* W. S. Hough, *Va. Agr. Exp. Sta. Bull.* 260, 1928.

TABLE 41

MEASUREMENT OF TYPES OF SPRAY PRODUCED BY VARIOUS EQUIPMENT WHEN OPERATED AT PUMP PRESSURES OF 250, 300, AND 400 POUNDS

Note.—Except as noted, 50-foot lengths of ½-inch hose were used.

Equipment	Spray Disk Opening	Pressure, 250 Pounds		Pressure, 300 Pounds		Pressure, 400 Pounds	
		Volume per Minute	Spray Drive	Volume per Minute	Spray Drive	Volume per Minute	Spray Drive
	Inch	*Gallons*	*Feet*	*Gallons*	*Feet*	*Gallons*	*Feet*
1. Four nozzles..	1/16	4½	12	4⅞	15	5½	16
2. Four nozzles..	1/12	6¼	12	6¾	15	8⅛*	17
3. Four nozzles..	1/10	......	......	8½	15	10½*	18
4. Four nozzles..	⅛	......	......	13⅛*	†	......	......
5. Three nozzles.	1/16	3½	10	3⅝	13	4⅛	13
6. Three nozzles.	1/12	4½	10	5	13	6	13
7. Three nozzles.	1/10	......	......	6⅜	13	7¾*	14
8. Three nozzles.	⅛	......	......	9½	?	......	......
9. Double gun..	1/12	4⅛	11	4½	13	5⅜	15
10. Double gun..	1/10	5¾	11	6⅜*	15	7⅜*	17
11. Double gun..	⅛	8	11	9⅛	15	10⅛*	17
12. Single gun....	1/12	2⅛	9	2¼	10	2⅞	12
13. Single gun....	1/10	3	9	3⅜	11	3⅞	12
14. Single gun....	⅛	5¼	12	5¾	13	6¼	13

* Five-eighths inch hose, 50-foot length.
† Spray coarse and lifeless, drive very weak.

hands of the operator. A wet rod is difficult to handle, and the material may make the hands sore if they are soaked in it continuously.

For peaches, sour cherries, and small trees, a rod 6 to 8 feet long is sufficient. A 10-foot rod is needed for apples in bearing, and a 14-foot rod may be required if the trees are high. Very short rods are sometimes convenient for spraying the under sides of leaves on the lower branches and for work at close quarters.

11. *Control.* Cut-offs to stop the flow of the material both at the base of the spray rod and at the pump are advisable. The former is in use continually as the operator manipulates the rod and directs the spray. It enables him to save much material between trees and to make minor adjustments in the rod or nozzles without stopping the engine. At the pump a Y connection with a cut-off attached to each prong is best. If two leads of hose are employed, one may then be shut down for repairs without interfering with the other.

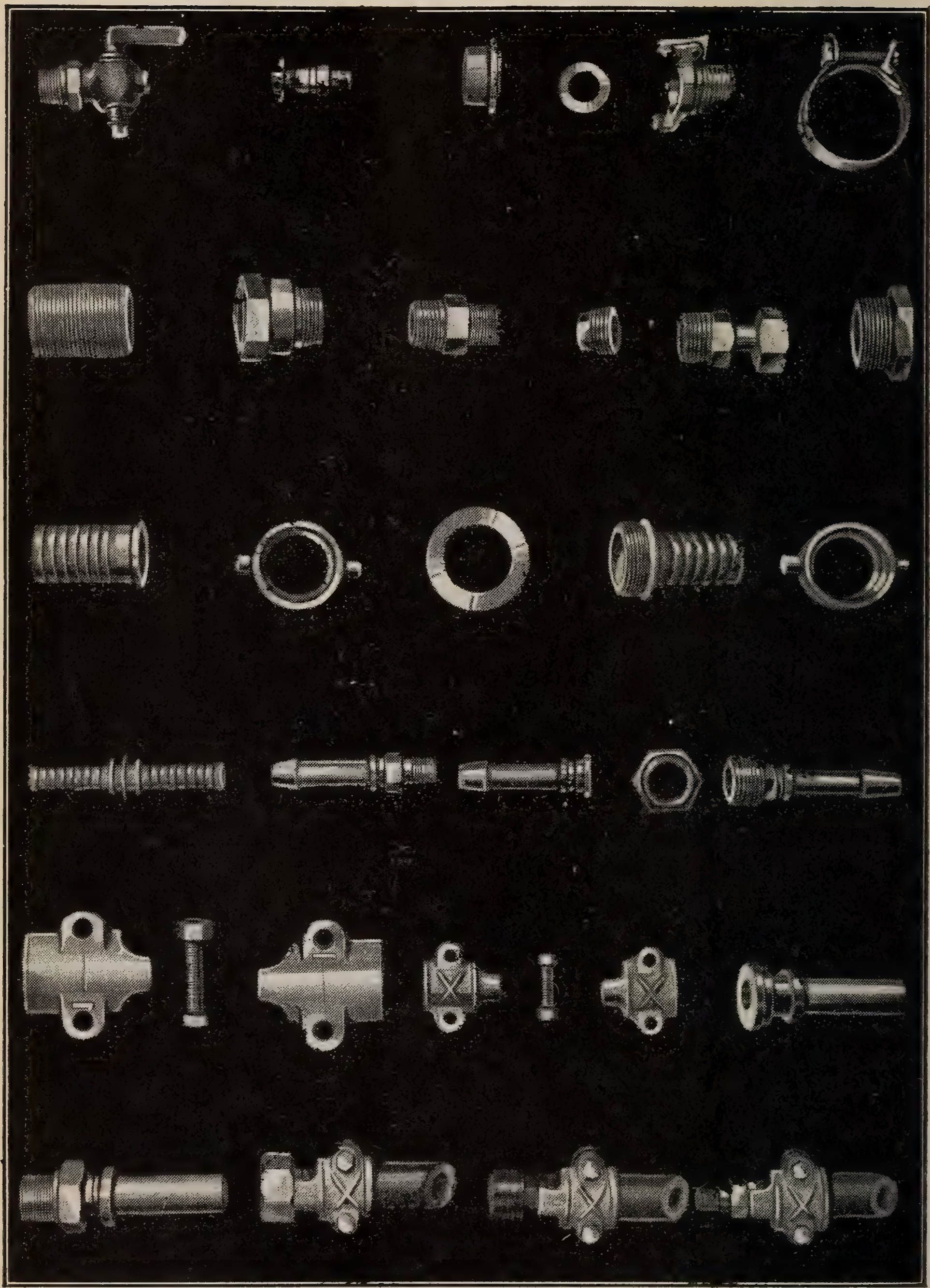
Cut-offs should resist corrosion, brass being the common material for them. They should be simple in construction and easily replaced, and the one at the base of the rod should be so designed that a partial turn will shut off the flow of material.

12. *Spray Hose.* Rubber spray hose for carrying the material from the pump to the rod or gun should be either 3/8, 1/2, or 5/8 inch in diameter. The 1/2 inch size should be used when the nozzles discharge more than 4 gallons per minute; the 5/8-inch hose is best for a discharge exceeding 6 1/2 gallons per minute. The actual inside diameters of 3/8-, 1/2-, and 5/8-inch hose are usually 5/16, 7/16, and 9/16 inch, respectively, but the former are trade terms.

Hose larger than 1/2 inch is inconvenient to handle, on account of its greater weight, and does not wear so well under orchard conditions as that of smaller diameter.

There is a great variation in quality of hose and no fixed standard by which its quality may be determined. It is classified according to the number of layers of canvas used in its construction, as 3-ply, etc. The quality of these plies varies greatly from fine duck to cheap sheeting. The greater the number of plies and the better the material used, the more durable the hose. The best hose usually has from 5 to 9 plies.

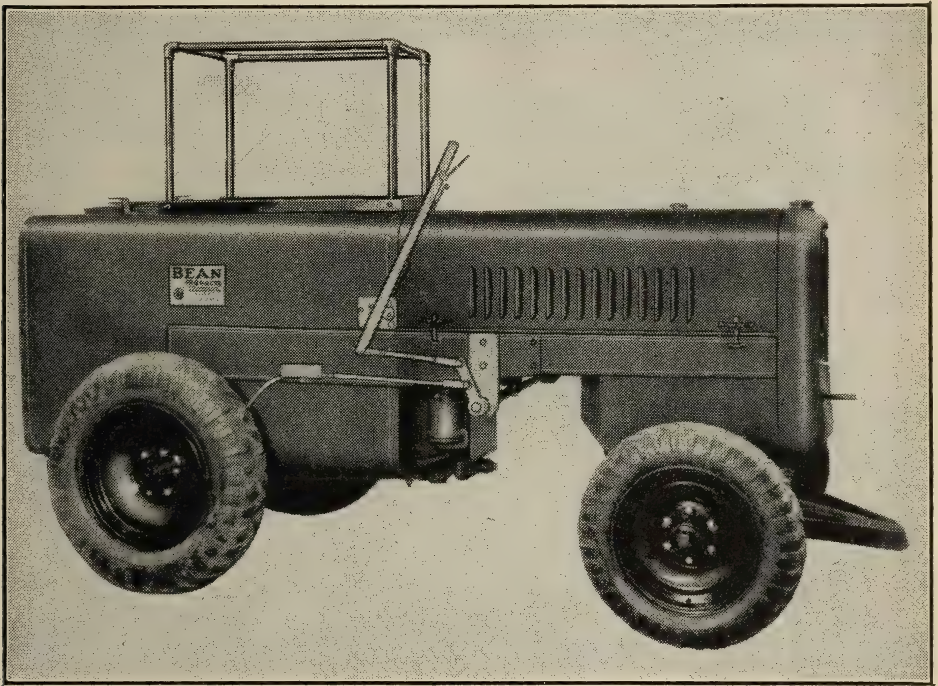
The length of hose required depends primarily on the distance between trees and also on the size of the trees, because more hose is needed to work about a tree with a top large in cir-



(*Hardie Mfg. Co.*)

Fig. 121. A page of accessory parts from a manufacturer's catalog.

cumference than one with a small head. The hose should be sufficient so that at least one operator may always be working on a tree other than that being sprayed by the man on the machine, in order that he may stay out of the mist and drip. The hose should also be long enough so that the machine may be moved without disturbing the operator until he has finished his job. Short lengths hurry the operator and are the cause of



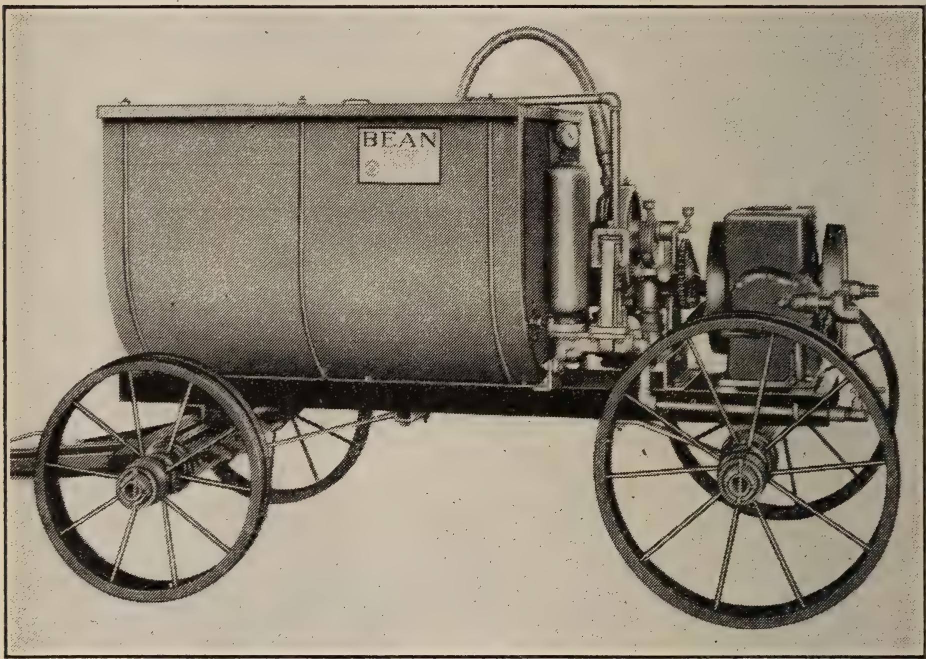
(*John Bean Mfg. Co.*)

Fig. 122. This is a modern type of machine, with center of gravity close to the ground, all parts covered and mounted on rubber. The tower on top of the tank is essential equipment.

many incomplete jobs. Hose 50 feet long has been found to be about the right length for ordinary apple-orchard spraying, giving freedom of manipulation without being too cumbersome. For trees planted closely and of small size, 30- to 35-foot lengths may be adequate. If one lead is used constantly from the tank, a length of 15 to 20 feet may be sufficient for this purpose. An outfit of large capacity, 15 gallons or more, may well be equipped with ⅝-inch hose for ground work and ½-inch hose on the tank.

If the hose connections from the pump are at the rear of the outfit, the hose may be attached conveniently and may easily be kept out of the way of the wheels.

13. *Couplings.* Hose couplings should be of brass with double-length shanks in order to offer plenty of surface for



(*John Bean Mfg. Co.*)

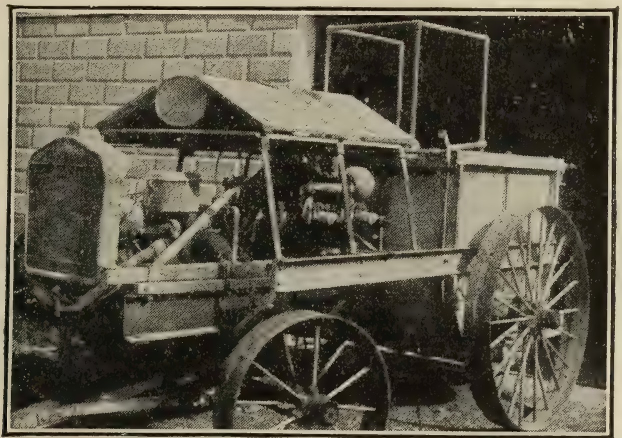
FIG. 123. A front mounting of the tank is unusual and puts much weight over the front axle which may impede turning. On a horse-drawn outfit it is easier to start the engine.

application of the hose clamps. The channels or waterways should be large and without obstruction, and the coupling should offer good wrench grips on both outer (female) and inner (male) sections. Short and cheap couplings give endless trouble through bursting or pulling out of the hose.

Brass hose clamps do not rust and resist chemical action. They should be strong and broad so that they may be well tightened without cutting into the fabric. Aluminum and iron clamps may be used. Wire clamps are difficult to keep tight and are likely to cut the hose.

The Traction Sprayer. The traction sprayer derives its power from the turning of the wheels on which the machine is hauled over the ground. Gears of a proper type transmit this power to the pump, through which the spray material passes. The pump may possess one, two, or three cylinders (Fig. 125).

It is evident that, when the wheels stop turning, the gen-



(*New Jersey College of Agr.*)

FIG. 124. The grower has installed an automobile engine of four cylinders in this outfit with a four-cylinder pump to make a very effective spray unit.

eration of power ceases and the pressure soon runs down. Since in orchard spraying the machine cannot be constantly in motion, the traction sprayer is not well adapted to the spraying of trees. It finds its greatest usefulness for the fruit grower in the spraying of grapes, berries, and other small fruits, where the machine may continue in motion. The machine must work rapidly enough to maintain the pressure and slowly enough to permit thorough coverage. A pressure chamber helps in this connection

Hand Sprayers. Small hand sprayers of varying types are available for the home garden. Among these, the knapsack sprayer is satisfactory, the operator working the pump and directing the spray at the same time. Much labor is involved, however; the tank when full is heavy, and the pressure secured is not great.

The barrel-mounted hand pump is a step in advance. It will operate one lead of hose and maintain a pressure of 75 to 150 pounds with a discharge of 1 gallon or a little more per

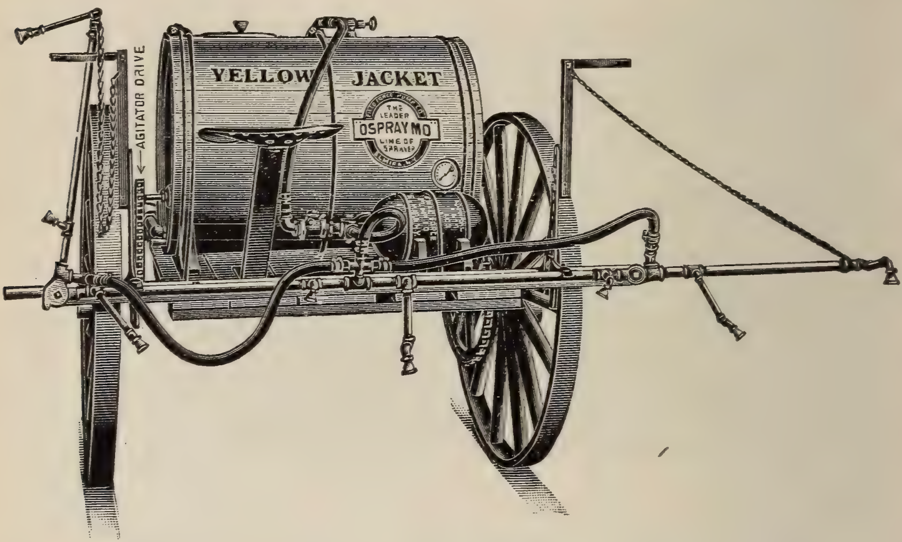
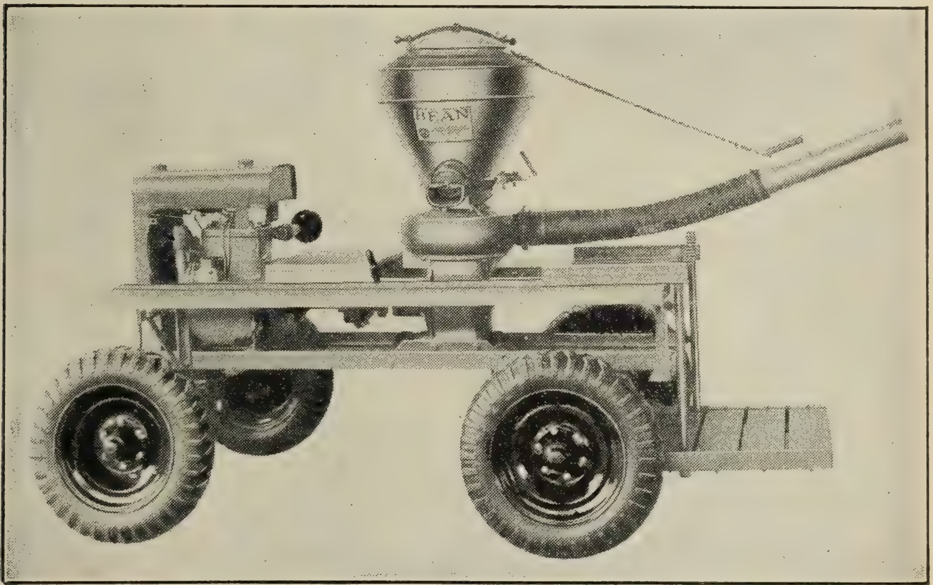


FIG. 125. A traction sprayer, pressure being generated as the wheels turn.

minute through a small-aperture disk nozzle. The cylinder should be of brass with a diameter of 2 to 2½ inches and a stroke of 3 to 4 inches. It should be equipped with an air chamber to aid in maintaining uniform pressure. All parts should be readily accessible. An agitator should be attached to the pump handle. The common mounting for the pump is on the head of the barrel as the barrel stands in a vertical position. The mounting, however, may be horizontal.

The barrel sprayer may be hauled on skids or a stone boat, placed on a wagon or mounted on wheels. It will answer for perhaps one or two acres of trees. Under the best of conditions, it entails much heavy labor.

A modification of the barrel pump is the one-cylinder double-action hand pump or the two-cylinder pump, mounted on a platform, with a vertical handle that the operator moves back and forth. He can put the weight of his body into the action and develop higher pressure with greater ease than with

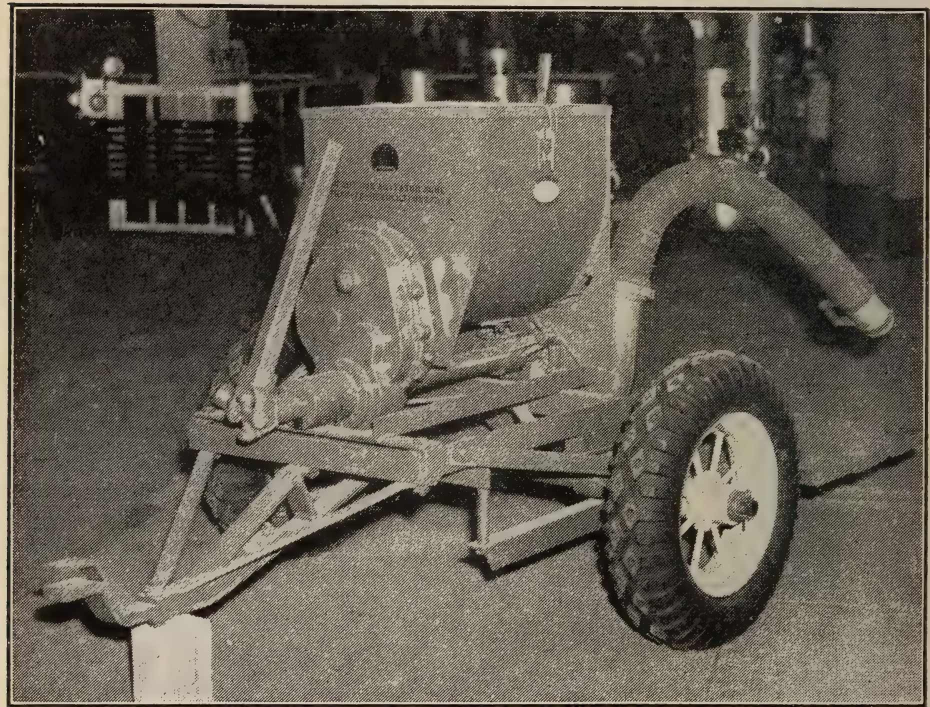


(*John Bean Mfg. Co.*)

FIG. 126. A modern duster. The spring platform on which the operator stands takes up shocks and jars and enables the operator to do a steady, even job.

the barrel-mounted pump. The spray material reaches the pump through a suction hose from a barrel or tank. Such a pump will run one lead of hose at 150 to 175 pounds pressure. It will handle up to 5 acres of bearing orchard and is the most satisfactory type of machine if the purchase of a power sprayer is not warranted. It is especially useful in orchards where the trees are only two or three years old, and it does the work rapidly with little waste of material.

(*h*) *Consider Important Mechanical Features of Duster and Equipment.* The duster is a simple machine compared to the liquid sprayer. It consists essentially of a gasoline engine, a hopper for the dusting materials, and a blower or fan which forces the material through a discharge pipe on to the trees (Figs. 126 and 127). It is usually mounted on a truck, or on



(*Niagara Sprayer & Chemical Co.*)

Fig. 127. This duster operates by means of a power take-off from the tractor.

skids for easy transfer to wagon trucks. Trailer dusters to attach to tractors are also available.

The material feeds through small apertures in the bottom of the hopper into the fan chamber. The fan, propelled by the engine and revolving rapidly, forces the dust out of the discharge pipe in a strong air blast. The operator manipulates the discharge pipe to send the materials to all parts of the trees.

The body of the duster, including hopper and fan, may be of light but durable material, as an alloy of aluminum. The hopper should be airtight to hold the dust which sifts through very small openings. Its capacity should be at least 100 pounds, equivalent to considerably more liquid spray, to avoid frequent stops for refilling. The opening for pouring the dust materials from the sacks into the hopper should be large enough to make the transfer easy. The machine should have a force feed to insure continuous and uniform delivery, with stiff revolving brushes inside the hopper to pulverize any small lumps and to work the material from the hopper through the openings into the air chamber. Machines are now being equipped with self-mixers to mix the dusts just prior to application.

The fan should be 16 inches in diameter with about six blades, making 3500 or more revolutions per minute.

A feed control lever, regulating the amount of material passing from the discharge pipe, should be located so that the operator may reach it conveniently. The lower section of the discharge pipe attached to the feed channel should be of reinforced rubber to provide flexibility in moving the pipe. For high trees a third section of pipe should be available. A discharge pipe 4 inches in diameter is standard.

Engines of 8 to 14 horsepower, depending on the size of the outfit, are required.

Traction dusters are used chiefly for field crops; hand dusters are very convenient for home gardens.

(*i*) *Consider the Advisability of a Stationary Spray Plant.* Stationary spray plants are in use in the Pacific Coast states, the Shenandoah-Cumberland region of the South, New Jersey, Ohio and Canada in orchards varying in size from 5 to 300 acres. Developed primarily to handle spraying problems on irrigated lands or on areas that, owing to special conditions, could not be sprayed at the proper time in the usual manner, they have steadily increased in number and have made a place for themselves in American fruit growing.

The stationary plant consists essentially of a pump driven by electric or gasoline power and a mixing unit for preparation of the spray materials, at a fixed point, with a pipe system of mains and laterals extending throughout the orchard, equipped with risers for hose connections at regular intervals. The spray material is applied to the trees in the usual manner by means of hose and rods, or guns, by men who work through the orchard, connecting the hose at convenient points.

Some of the advantages of such a system are at once apparent:

1. Spraying may proceed on schedule on wet or rough land. In the West, irrigation and the use of the portable sprayer often present a difficult problem. In all sections periods of heavy rains often interfere seriously with the spraying operations, because the ground is too soft to haul the machines over it. In sections where hill orchards and plantings on rough lands are common, the stationary plant aids in solving the serious problem of doing a thorough and timely spraying job.

2. The necessity for hauling machines between closely planted trees and those loaded with fruit is eliminated.

3. Damage to cover crops or intercrops is reduced.

4. The application of materials to the trees goes on without interruption. There is no time out for refilling. The amount of effective work accomplished by a given crew of men is increased from 25 to 50 percent over the portable outfit.

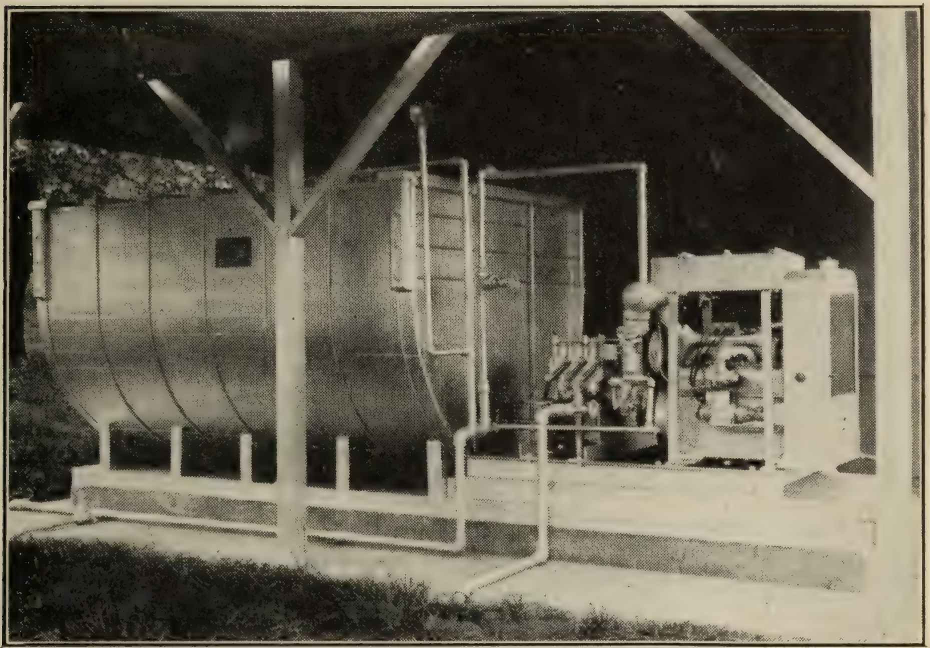
5. It releases teams, tractors, and the men to drive them, for other forms of work.

6. There is less wear and less depreciation on machinery in a fixed location and on a solid foundation than on that hauled through the orchard. Its period of service is therefore extended. Some plants have given satisfactory service for 15 years.

The chief advantage, already implied, is that it makes the grower almost independent of soil or weather conditions, so far as his spraying program is concerned.

On small enterprises, especially where teams or tractors are needed for other work and must be retained whether used for spraying or not, it is probable that the portable oufit is more economical. For the large enterprises and where conditions require numerous applications of materials, the stationary plant is rapidly gaining in favor.

The Purdue Agricultural Experiment Station found in its own orchard that over a four-year period the cost per 100 gallons of spray material for labor, power, depreciation, and



(*Ohio Exp. Sta.*)

FIG. 128. The units in a central or stationary spray plant correspond to those in a portable outfit but provide greater power and capacity.

interest on investment was 15 cents less for the stationary unit than for a portable outfit.

If it seems wise to consider the installation of the stationary unit, consult the local experimental station for latest findings and recommendations.

(*j*) *Select Machinery and Equipment.* Basing his judgment on the facts presented in the foregoing sections, the grower is now ready to make his choice of machinery and equipment.

He will try to keep his investment and overhead charges as low as is consistent with satisfactory performance and service. He will give preference to standard outfits of proved ability and those for which repairs and service are readily available. He will keep in mind that outfits that will do what he requires of them well within their resources and without undue strain constitute better investments than those constantly crowded to the limit. The delivery required of the machine should be 2 to 4 gallons less than its actual capacity if it is to have a long period of satisfactory service. If it requires more than five to six days to cover the orchard with a liquid sprayer, the grower needs more machines or machines of greater capacity.

In addition to the facilities actually needed under normal conditions to do the work at the proper time in the right way is the question of what facilities the grower ought to have in reserve as an insurance against emergencies and seasons when the weather seriously cuts down the period of effective applications. He has in mind the actual and probable future labor supply and its quality, upon which he must depend. His selection is based on a knowledge of his own orchard conditions and problems, and on judgment carefully formed in the light of them.

5. Applying Materials. The control program may break down at the point of application of the materials. Adequate machinery and equipment, proper materials, and a careful observance of the time limits for their effective use may fail to achieve satisfactory results because of incomplete plans and faulty methods of application of the materials.

Procedure:

(*a*) Planning facilities.
(*b*) Applying spray materials.
(*c*) Applying dust materials.
(*d*) Caring for machines and equipment.

(*a*) *Planning Facilities.* For liquid spraying convenient and adequate water supply is of first importance. If the water must be pumped, the reservoir in which it is stored should have ample capacity for at least a full day of spraying, and an even greater reserve is good insurance against delays and accidents. A storage that permits filling the spray tank by gravity is best. Even though the supply is taken from a running stream or lake, many growers prefer to pump the water at first into storage tanks from which it may be run quickly into the sprayers. A central water supply equally distant from all outer points of the orchard is good for large enterprises. A man may be located here to mix materials and have them ready when the sprayers arrive.

Some growers prefer a number of smaller filling stations throughout the orchard rather than a single larger central supply station. This arrangement saves time spent in haulage, and it permits work to go on even should a supply unit be out of commission.

If the enterprise is large enough to warrant the extra investment, a spare outfit at the central point, ready to operate, will save time. As the empty machine comes in, the crew simply changes machines and goes on.

Equipment for preparing the formulas that are made up by the grower has already been described in connection with the materials themselves. Accurate scales and measuring devices should be on hand. Stocks of repair parts and extra parts for the machines should be accumulated before the season begins. The grower can much better afford to carry the slight extra investment in such parts than to be compelled to suspend operations while waiting for them to arrive. Some manufacturers attempt to give prompt service on repair parts and accessories; others do not. All are very busy while the spraying season is on and cannot handle orders with as much dispatch as during the slack season. Among extra parts which the grower should have in reserve are:

Agitator paddles	Pump packing
Cylinder-head gaskets	Repair tools
Connecting rods	Spark plugs
Disks for nozzles	Spray hose
Gaskets for nozzles	Spray rods
Hose clamps	Stove bolts
Hose connections	Suction hose
Hose washers	Suction strainer for hose
Nozzles	Valve balls
Pistons	Valve seats
Plunger cups	Valve springs

Parts should be classified and stored in separate compartments, and those subject to corrosion should be protected by a coating of heavy oil or grease.

For very extensive operations, a complete extra outfit or an extra engine and pump with all connections should be held in reserve.

(*b*) *Applying Spray Materials.* The careful orchardist will plan his organization of labor and the function of each workman thoroughly before the machine goes into the orchard. An outfit capable of carrying one lead of hose will require two men, one to spray and the other to drive team or tractor. A boy may do the driving, and many a good workman in the orchard has served his apprenticeship in this way. With a large capacity outfit carrying two leads of hose, three persons will be needed. If the trees are large, one man should spray from the tank and the other from the ground, making the application from both sides of the row. A tower will be needed for tall trees. The men can alternate work so as to distribute the more difficult roles fairly between them.

With extra-large machines carrying three leads of hose, an arrangement of one man to a row on the ground and one man on the tower, covering the tops of both rows, works well when the rows are sufficiently close together.

A spraying method that has given satisfaction is for the man on the ground to spray the inner parts of the tops first. This eliminates the necessity of walking in under a dripping tree as must be done if the outer parts are covered first. In using a gun, it is absolutely necessary to get under large trees to do a good job; in using an extension rod with an angle nozzle, the operator may move about the exterior circumference of the head, spraying inward and upward.

Air is seldom completely still in the orchard. The side

(*Caterpillar Tractor Co.*)

Fig. 129. Both men are spraying from the ground but do not work on the same tree at the same time. This is a good outfit for hilly land. The power is from the tractor. This is a Virginia scene.

where the operator must spray against the wind is the most difficult to cover. The operator should direct the spray through the tree, making certain that the material carries well through to the opposite side. The back sweep of the wind will insure coverage of the windward sides of the leaves and fruit. To spray only with the wind means that only the surfaces on the windward sides will be covered, as the spray will not drift back against the air currents. In spraying from one position, however, many more of the leaves will be turned and well coated with material when high pressures are used than when ordinary pressures are employed. It is not expected that the spraying operation will be carried on in the teeth of a strong wind, but it is seldom that a still day is available for the work, especially in the early spring. A steady wind from a constant

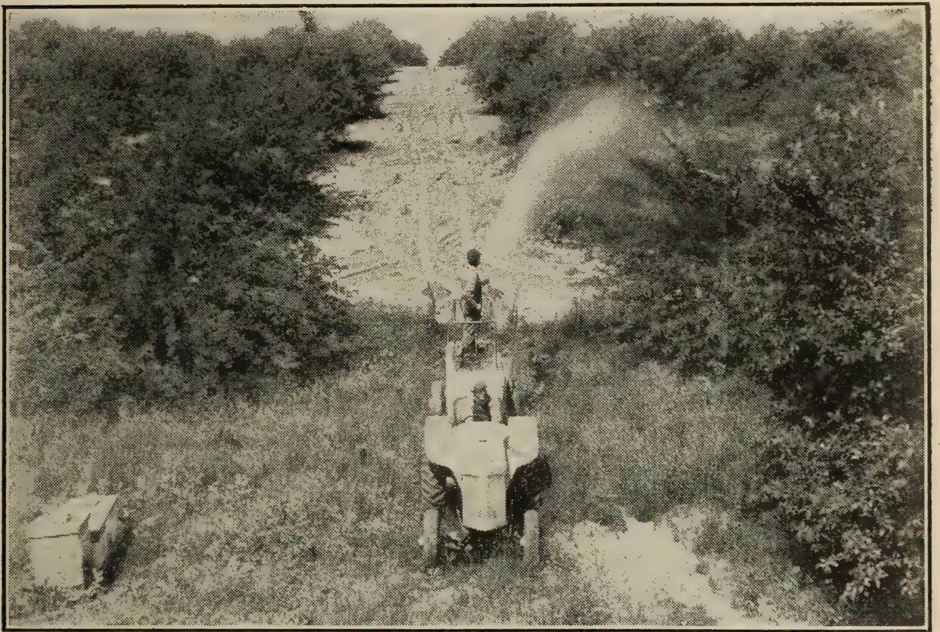
(*Mich. Exp. Sta.*)

FIG. 130. These men are using two platforms—one improvised at the front of the sprayer. They are using single-nozzle guns and a pressure of 600 pounds. Note how the mist hangs on the tree.

quarter gives less difficulty than a fitful, shifting breeze, whose antics cannot be anticipated.

A method sometimes employed is to spray only with the wind; that is, to spray the windward sides of the trees and then wait for the wind to change before completing the job. This practice has not given good results and is not recommended. Careful examination has disclosed many uncoated areas in the tops, and very poor aphis control has been secured. In sections where prevailing winds are from one quarter the grower might wait a long time for the wind to change, but the insects and diseases that he seeks to control are active all the time.

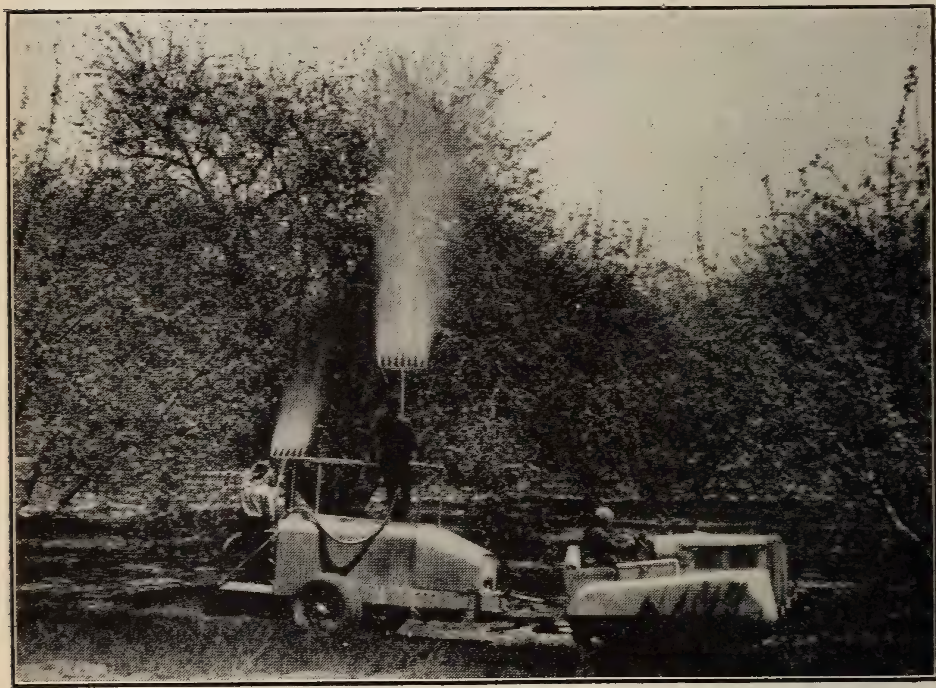
Whatever the particular procedure, which, after all, the grower must determine in the light of his own conditions, a fine, driving, cone-shaped spray that penetrates everywhere and settles on the fruit and foliage in small globules is best for most purposes.



(John Bean Mfg. Co.)

Fig. 131. Spraying from the top of the tank alone is not the best procedure. It is not possible to reach the lower sides of the low branches. Note bees at left. They should be removed before the Calyx spray is made.

The orchardist must watch particularly to see that the surfaces away from the wind are well coated, those high up in the top often being left unprotected. He must keep in mind that the protruding tips of branches on the outer circumference of the head are easily missed. A spray gun may be doing a good job at close range but delivering only coarse spattering drops on the parts farther away. The temptation in using a gun is always to increase the drive and decrease the fineness of the spray, and to hurry the operation too much. On the other hand, a gun held in one position wastes material and may cause injury and burning of the foliage and fruit. Burning is especially likely to occur on very humid, warm days when using materials that are naturally quite caustic, such as concentrated lime-sulfur.



(*Caterpillar Tractor Co.*)

FIG. 132. Note how the spray from the lower gun is driving through the tree.

A disk nozzle may deliver an uneven spray, heavier on one side of the cone than on the other, or the cone may be entirely hollow in the center. This may be due to a partial clogging of the nozzle or to mechanical imperfections.

In using sprays carrying coarse materials, as self-boiled lime-sulfur or the wettable sulfurs, a gun will operate with less clogging than a disk nozzle.

The careful operator will cease operations occasionally and inspect trees that have been covered to determine how well the job has been done, and to correct practices and change equipment when needed. A beginner can employ his time to no better advantage than by watching carefully the spraying methods

(*Caterpillar Tractor Co.*)

FIG. 133. An empty line sulfur drum is used as a means of support on the tank. It is a very satisfactory device. This tree is being well sprayed. The operator on the rear platform can cover the lower branches if he is careful.

of a skillful operator who grows good fruit, or better still, by spraying with him for a time.

The amount of material used is not necessarily an index of proficiency but may serve as a general guide. A knowledge of the quantity is also useful in compiling the order. It varies, of course, with the size of the tree. A tree with thin foliage or triangular outline requires less material than one with dense foliage and a full head circular in outline. The amount of wind present during the spraying operation causes more variation in quantity of spray used than any other factor. The nature of the organism to be fought is also a factor. Aphis control, for example, requires a thorough drenching of the affected parts and the consequent use of relatively large quantities of material. For the dormant sprays 6 to 9 gallons, and for the summer sprays 8 to 14 gallons, constitute standard applications on mature apple trees in most regions. Since every part of the trunk and branches must be covered in some dormant sprays, the amount of material used may be as great as for a foliage spray.

(*c*) *Applying Dust Materials.* The proper time for dusting is when the air is still. There is little waste of materials under such conditions, and the dust hangs in a cloud or dry fog about the trees for a considerable period. The proper atmospheric conditions are found as a rule in early morning or late evening. Most orchard dusting, with the exception of nicotine applications, is done at these times. The presence of more moisture on the leaf surfaces at these periods than at midday causes the dust to stick better. Sulfur dusts adhere well even when the foliage is dry. Many dusts now in use contain adhesive materials. Some growers attach lights to the machines and operate them through the night; air conditions are good then, and the job is hastened by almost continuous operation of the machines.

Nicotine dusts, in order to be effective, should be applied when the temperature is high. Fumes are generated more readily then than at lower temperatures, and control is more effective. For this reason they are best applied at mid-day when the air is quiet. Breezes dissipate the fumes before they can be wholly effective. In sections where the air is seldom quiet at mid-day, early evening is often the best time to make the applications. It is a waste of time and money to attempt to control aphis with nicotine dust when the wind is blowing or the temperature is below about 65° F. The higher the temperature, the better.

Dusting before rainy spells is just as important as spraying ahead of a rain, for the control of fungus diseases. Some of the dust will be washed off, but enough will remain to inhibit spore germination.

The arrangement of supplies is simpler than for spraying. Sufficient materials for a half day may be carried on the

(Niagara Sprayer & Chemical Co.)

FIG. 134. The duster in operation. The discharge pipe is pointed a little too high so that dust is going over the top of the tree.

machine, or sacks of material may be placed at the ends of rows.

In covering the trees, it is not customary to stop, the machine moving constantly over the ground. For small trees a fast-moving team or tractor is best; for large trees, a slow movement gives more time to cover the trees thoroughly. With small trees a quick puff made by opening the feed lever as the discharge pipe passes the tree and then shutting it off again is sufficient. The discharge pipe must be moved enough so that the entire top, including exterior tips, is covered. This is a matter of seconds. The operator must be agile in order both to do a good job and to conserve material.

Trees not exceeding in size a commercial peach tree may be dusted from one side of the row when dusting conditions are good. It is good practice, however, to put on the different applications from alternate sides of the row. Thus, if the first application is made from the east side, put on the second from the west.

Large trees should be dusted from both sides. Split ap-

(*Mich. Exp. Station*)

FIG. 135. Dusting at twilight. The air is still. Note how the dust hovers in the tree at the right.

plications are sometimes made, that is, dusting one side when conditions are right, and dusting the other side a few days later when the drift of the wind is in the opposite direction. Under such conditions about half the material needed to cover the tree completely is used at each application. Nicotine dusts should be put on in a single application to secure most effective control.

An upward and downward sweep of the discharge pipe with a horizontal stroke across the top gives an even coverage with a minimum of material. To send the material to extreme heights, give a sudden upward fling or flirt of the pipe at the top of the regular stroke. For very high trees, an extension of the discharge pipe may be needed. The parts of the tree close to the ground and near the machine are most likely to be missed. These may be covered by a horizontal blast to the rear as the machine leaves the tree.

Regulate by the feed-control lever the amount of material

(*Niagara Sprayer & Chemical Co.*)

Fig. 136. A self-directing duster for use on peach and other relatively small trees. Its adequacy and economy are not yet fully determined.

used. Since dusts are expensive, it is important that as little as possible be wasted. It is just as important to use enough to do a good job. A check on the quantity being used may be obtained by recording the amount of material put in the hopper and dividing it by the number of trees covered. The quantity per tree varies with the size of the tree. The Niagara Sprayer and Chemical Company has compiled the data in Table 42 for average conditions. The quantities are subject to change to meet individual requirements.

TABLE 42

Quantity of Dust to Use at Each Application

Amount per Tree, Pounds

Crop	1 to 5 Years	5 to 10 Years	10 to 15 Years	15 to 20 Years	20 Years and Above
Apples	⅛	¼ to ½	1	1½ to 2	2 to 3
Cherries	⅛	¼	½ to ¾	1	1 to 1½
Peaches	⅛	¼ to ½	½	½	½
Pears	⅛	¼ to ½	½ to ¾	1	1
Plums and Prunes	⅛	¼	½ to ¾	1	1
Quinces	⅛	¼	⅜ to ½	½	½

(*d*) *Caring for Machinery and Equipment.* During the operating season keep all working parts thoroughly lubricated. Seek to anticipate difficulties and make adjustments before trouble really occurs. Put all liquids carrying materials in suspension through a strainer in the top of the spray tank; wash all materials in powder form through the strainer, to prevent the entrance of substances that may clog the valves or nozzles.

At the close of each day of work, put the suction hose from the pump into clean water and flush the pump, hose, and nozzles until only clear water comes from them. The equipment will thus be freed of corrosive materials and will be ready for the next day's work.

Drag the hose over the ground as little as possible, except when actually spraying. Disconnect it at the machine when going to refill, or coil upon hangers at the end of the machine. Do not permit kinks to form in it, as these injure the fabric.

When the spraying season is over, flush thoroughly, with clean water, all parts through which the spray materials move. Drain the pump, engine, and tank. Run some used lubricating oil through the pump to prevent rusting during winter. Store the hose in a cool, dark place, since it deteriorates in heat and light. Coil it over a barrel elevated off the ground, or stretch it out on a bench or shelf in such a way that it will drain out completely. Do not suspend the hose on nails or from a few points, as cracking is likely to result.

In the spring, get the machine out ahead of time; go over all the parts and "tune" it up ready for active use.

The care of the duster is simple. Drain the engine at the end of the season, clean the hopper thoroughly, and coat with heavy oil or grease all parts subject to corrosion. If dormant dusts are used which cake on the machine parts, especial care must be taken to clean the machine well.

6. Determining Costs of the Spraying Program. Costs of the spraying program depend upon a number of factors. The cost of the materials themselves may be easily determined, if the dilutions used, the number of applications to be made, and the average amount applied per tree or other unit are known.

The cost of making the applications is so variable that average figures are of little value to the individual grower. The price of labor, the capacity of the outfit, the accessibility of water and other supplies, and the topography of the land are among the factors that determine costs of application.

In the Hudson Valley of New York, in 1931, it was found that the average cost of spraying for the season was $2.57 per 100 gallons of spray applied, or $15.68 per acre, which would indicate that slightly over 600 gallons of spray material was applied per acre. It must be stressed that this is not enough to give complete control of insect and disease injury in a normal season on full-grown trees. It is merely an average for 509 orchards where the number of applications varied from no spray on 23 orchards, to six or more sprays on 57 orchards. Although the trees ranged from newly planted to some over 30 years of age, the average for trees in the 486 orchards (4319 acres) that were sprayed was 3.8 applications at a rate of 5 gallons per tree per application. To grow a crop of good quality it is rarely possible to spray less than six times in the

Hudson Valley. It was figured that each spray cost an average of 28 cents per tree for trees 28 years of age and over, and an average of 9 cents per tree for trees of less age.

These figures include the cost of the spray material, the cost of labor, sprayer cost, upkeep, depreciation, and the power for drawing the outfit. It has been shown that the New York orchards sprayed most often and most thoroughly had yields of marketable apples sufficiently high to keep production costs down to an average of 73 cents per bushel. Of this cost about 25 cents was for spraying (see Table 43).

TABLE 43

Cost of Producing Apples According to Number of Sprays and Amount of Spray Applied per Tree per Application, Western New York and Hudson Valley

Cornell Extension Bulletin 355

		Cost per Bushel
Less than 5 sprays	Light applications	$1.19
	Heavy applications	$1.04
5 or more sprays	Light applications	$0.85
	Heavy applications	$0.73

This emphasizes that few sprays and light applications may be expensive, whereas more numerous sprays and heavier applications may, by increasing the marketable product, be economical.

The cost for material, labor, power for pulling the outfit, the use of the sprayer, preparing and applying the material, for 80 fruit growers in Berrien County, Michigan, for 11 applications in 1935 was $27.16 per acre, 12 cents per bushel of fruit harvested, or 55 cents per tree. Most of the trees were between 15 and 30 years of age. Where trees were less than

15 years old, the total spraying cost was 44 cents per tree compared to 62 cents per tree in orchards 30 or more years of age. The total cost per 100 gallons of spray applied averaged $1.37 in these orchards.

A similar test in 1931, in the valley area of Shenandoah-Cumberland district, showed spraying and dusting costs to average $17.30 per acre. Dusting was rarely done, and for all practical purposes, 6 spraying applications would include the entire operation. Of the 402 acres of trees studied, 261 acres were between the ages of 15 and 30. There would be a slight increase in cost for the 84 acres which were over 30 years of age and a slight decrease for the 57 acres which were from 10 to 14 years of age.

In the Hudson Valley of New York 4 applications of dust were applied for the same cost as 3 sprays. In western New York the cost of applying 8 dusts was about the same as that for 7 sprays. These costs include the material, labor, and equipment charges. Materials to spray an acre once cost 24 percent less than dust materials. Interest, depreciation, repair, gas, and oil for the sprayer were 73 percent more than the corresponding costs for the duster.

7. Adopting Control Measures Other Than Spraying and Dusting. Sometimes measures other than the application of materials to the trees may be employed to advantage by the orchardist.

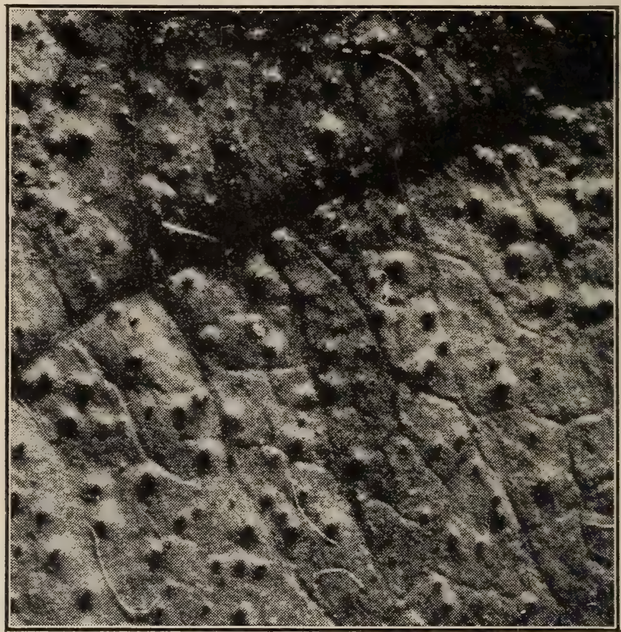
The burning of adjacent hedgerows and cleaning up the boundaries of the orchard aid in control of such insects as plum curculio and lessen the danger from mice and rabbits.

There is some evidence that thorough spraying of the apple leaves on the ground in early spring may help in scab control.

The only method known at present for control of cedar rust is the removal of all cedars within a radius of one mile of the orchard.

The peach tree borer is controlled best by the use of ethylene dichloride or paradichlorobenzene, as indicated under General Information at the close of this chapter. Neither it nor the flat-headed and round-headed apple tree borers can be controlled by spraying or dusting the tree.

Fall and early spring plowing destroys many larvae of the Oriental fruit moth and aids in scab control by turning under the old leaves from which the first infection comes in the spring. The use of parasites, especially macrocentrus, to control Oriental fruit moth is to be considered.



(N. Y.-Geneva Exp. Station)

Fig. 137. Fruiting bodies (perithecia) of apple scab on an overwintered apple leaf from which spores will be discharged during spring rains.

Fire blight of the apple, pear, and quince, a bacterial disease, does not yield to the spraying or dusting program and must be fought by different methods.

Fertilization and special stimulative treatment, including cultivation of affected trees, are sometimes advisable. By increasing their vigor their resistance is increased and their recuperation is hastened. This method is employed often in cases of extreme defoliation of the trees in the growing season and in meeting attacks of the fruit tree bark beetle of the peach. Trees suffering from winter injury may, to their advantage, receive a special application of nitrogen-carrying fertilizer.

Some varieties are more resistant to disease and winter injury than others. Thus, Tompkins King, Grimes Golden, and Twenty Ounce are susceptible to collar rot about the base of the trunk. Northern Spy and McIntosh are resistant. Growers may sometimes resort to top-working desirable varieties with weak trunk characters, on more hardy and resistant kinds, as indicated in Chapter VII, "Propagating Fruit Plants." Physiological troubles such as bitter pit, drought spot, and cork are often decreased by improving the moisture conditions of the soil.

(*N. Y.-Geneva Exp. Station*)

FIG. 138. Cross section of perithecium showing the spores formed, and ready to emerge from leaf in Fig. 137.

When the balance between organisms is destroyed, nature intervenes to restore it. The San José scale is the prey of many species of ladybird beetles, some fungi, and at least nine species of Hymenoptera. However, the pests are likely to make severe inroads and cause heavy losses for several years, until natural enemies become abundant. Some pests yield, either not at all or only in part, to such enemies, so that the fruit grower may not depend on natural enemies except to supplement his own program of control.

It is best to rely on the experiment stations and other public agencies serving the section in which the fruit enterprise is located, for the detailed information on which proper procedure must be based.

It is not possible to include here a complete treatment of the various insects and diseases that affect fruit trees. Some are serious in one section and less so, or not at all, in another. Some are seasonal in their inroads, being destructive one year and unimportant another. New and more complete knowledge concerning them and the methods for their control is constantly being acquired and is available from authoritative sources. The enterprising grower will keep in touch with the experiment stations and government agencies and will study their findings. He will develop a library of good books and publications on the control of insects and diseases of the orchard and will revise it constantly to keep it up to date.

GENERAL INFORMATION

Controlling Peach Tree Borer

The peach tree borer (*Sanninodea exitiosa*) kills many peach trees and destroys the vigor of others. It passes the winter in the larval form: if small, usually on the bark in silken protective coverings; if larger, in burrows under the bark. In the far South the larvae feed all winter instead of hibernating.

In the spring the boring is continued and a cavity is formed several inches long in the sapwood, just beneath the bark. Gum and sawdust collect at the openings of the burrows and about the base of the tree. As many as 50 or more borers may work in a single tree. Most of the work is done about the trunk just at or below ground level, though sometimes at a greater depth.

When full grown, the larva leaves the burrow and pupates in a dark round cocoon, usually attached to the bark near the ground. The adult fly emerges in about a month, and eggs are soon laid by the female, singly or in small clusters on the lower trunk. The eggs hatch in about ten days, and the larvae start their burrows at once.

Control. Larvae may be dug out with a knife and wire. This method is not so satisfactory as the use of ethylene dichloride.

Slowly stir 9 parts by volume of ethylene dichloride into 1 part by volume of potash fish-oil soap. Add 9 parts of water to make a 50 percent stock emulsion. Dilute, and apply as recommended in Table 44. This material may be sprayed or poured on in the fall, winter, or early spring as long as the weather is warm. Apply the emulsion about the base of the tree and on the lower trunk. A knapsack sprayer or a sprinkling can with a small spout may be used to advantage. Place a few shovelfuls of soil around the trunk after the material is applied. Ethylene dichloride stock emulsion can be bought ready for dilution according to the manufacturer's directions.

TABLE 44

ETHYLENE DICHLORIDE STOCK EMULSION DILUTIONS

Quantity of Water of Stock Emulsions to Use to Get 10 Gallons of Diluted Emulsion at the Strength Used

Age and Size of Trees	Water	50% Stock Emulsion	Strength of Diluted Emulsion	Dosage of Diluted Emulsion for Each Tree
			Percent	*Pint*
6 years and older, average and larger size........	5	5	25	½
6 years and older, small..	6	4	20	½
4 and 5 years...........	6	4	20	½
3 years.................	7	3	15	½
2 years.................	7	3	15	¼
1 year..................	8½	1½	7½	⅛

COMMUNITY STUDIES

1. Visit several growers of each tree fruit of commercial importance in the section. Determine:

(*a*) The acreage and varieties.
(*b*) Injurious insects and diseases for which control measures are employed.
(*c*) The materials used and proportions.
(*d*) Cost of materials.
(*e*) Time, number, and cost of applications.
(*f*) Method of application.
(*g*) Acreage or number of trees and age of trees treated per day or hour.

How much of this time is spent actually in applying the materials to the trees?

2. Put these control measures together into a schedule or program for the season.

3. Study the spray outfit as to cost, type, power of engine, capacity of pump, durability, ease of handling, accessibility of parts, ease of obtaining repair parts, type of gun or nozzle, pressure employed. Investigate facilities and devices for saving time in mixing materials and filling spray tank and for keeping machine at work continuously. If a duster is used, get growers' opinion of its place in the spray program, the costs as compared with liquid spraying, and the effectiveness of control.

4. From the foregoing information, compute the actual spraying costs in the various orchards.

5. Prepare a brief life history of the important insects and diseases of the section.

Secure from the local state experiment station or college of agriculture the latest information concerning control measures and materials.

6. With this information, suggest improvements in the growers' programs as to materials used, method and time of application and refinements in the machine itself that will give more effective service.

7. Work out a complete spray schedule for an average season, with costs, for a 20-acre unit.

CHAPTER VII

PROPAGATING FRUIT PLANTS

Fruit varieties, with rare exceptions, do not come true from the seed. Thus the seeds of a Stayman Winesap apple might give rise to red, green, or striped, sweet or sour, large or small apples. Some might resemble the parent variety, but many of them would be worthless, with the chances slight that from thousands of seeds there would come a single sort that was an improvement over the parent.

For this reason it is necessary to secure new plants of a given variety by transferring vegetative parts of that variety to a stock upon which these parts may grow, or by rooting the vegetative parts without the use of a stock, or by inducing the development of roots on the mother plant which may later be separated and used for new plants. The name given to the process of making the transfer depends upon the nature of the particular method employed and the vegetative parts used. Thus we have *cleft grafting, whip grafting, shield building, cuttings, layerage, etc.*

It is necessary also at times to resort to one of these processes to convert undesirable varieties to desirable kinds. Perhaps the orchard trees have proved untrue to name. The purchaser of McIntosh or Jonathan may find that he has Ben Davis. He may graft his trees to a more desirable variety.

Again, it has been found that large blocks of a single variety may prove unproductive, as indicated in the chapter on pollination, or this may be true of two mutually incompatible varieties. The grower resorts to graftage to develop trees, the blossoms of which will pollenize his orchard and give him a set of fruit.

Again, a variety may be very desirable in itself, but may possess poor tree characters in that it may be very susceptible on the trunk or in the crotch at the base of the main branches to winter injury, materially reducing the life and fruitfulness of the tree. By graftage, the trunk of a hardier, more resistant kind may be substituted, and upon it may be built the top or head of the variety desired.

New varieties may be induced to bear fruit earlier by grafting them on mature trees than by growing them from nursery trees. This saves a number of years in testing them to determine their value.

It is evident, therefore, that the fruit grower should possess a knowledge of a few simple and effective methods of procedure under the circumstances outlined. If he lacks it, there may usually be found in fruit-growing sections a few men who are very skillful in the various forms of plant propagation and who may be engaged to do the work.

Operations and Factors:

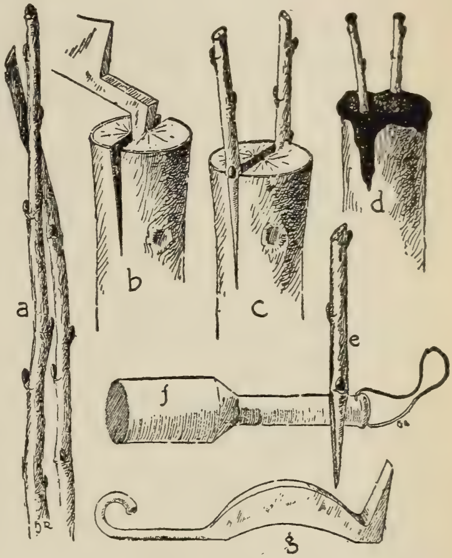
1. Cleft grafting.
2. Inlay or bark grafting.
3. Whip grafting.
4. Shield budding.
5. Bridge grafting.
6. Propagating by cuttings.
7. Propagating by layers.
8. Grafting preparations.

Since growth takes place in the cambium cells beneath the inner bark, it is necessary in all forms of grafting and budding that the cambium tissues of the stock and the part grafted upon it be put in contact with each other. This is the fundamental consideration whatever the method.

1. Cleft Grafting. Cleft grafting is usually employed when it is necessary to graft a new top on a tree which is several years old. Even mature trees may be grafted, but the difficulty increases with the age of the tree and the size of the branches.

The process of substituting an entire new top of a different variety is called *top-working*. The particular method used depends upon the age of the tree and the size of the branches.

Cleft grafting is the most common form of top-working employed by the grower; as the name implies, it consists of making a cleft in the stock into which the graft or cion is inserted (Fig. 139). The operation is feasible upon limbs varying in size from those just strong enough to hold the cions firmly in place to those so large that the clefts or wedge-shaped openings in the branches can be made with difficulty. On trees set in the orchard only from one to two or three years, the cions are usually placed in the trunks; on older trees they are placed in the branches.



(N. J. Exp. Sta.)

FIG. 139. Materials for cleft grafting. (*a*) Cions. (*b*) Cleft in stock ready for insertion of cions. (*c*) Cions inserted in cleft. (*d*) Cleft and cion tips waxed. (*e*) Side view of cion showing wedge shape of cut portion. (*f*) Mallet for making cleft with chisel. (*g*) Grafting chisel—note curved blade which prevents tearing of the bark. A sharp knife is also needed for shaping the cions.

The tendency of the cions is to grow directly upward. If they are inserted in lateral branches, they will not assume the same direction as these branches but will turn and grow upward. In determining the branches to be grafted, it is important to select, as far as possible, those that may be grafted near the ground. Otherwise the new head may be very high, the fruit being borne at the ends of long, polelike branches.

Take at least two years to work over trees of considerable size. All grafts may be set in one year, but part of the top should be left to be removed later. It is not safe to cut off the entire tops of such trees in a single year. The trees may die or the cions may be forced into excessive growth, breaking out by their own weight or being killed in winter. Also, the crotches and main branches, being unduly exposed, may suffer from winter injury.

It is not necessary to work over every branch of appreciable size. Select those on which grafts, by proper pruning, will develop a good top. On small trees, three or four grafted branches, and, on larger trees, six to eight will usually suffice.

Perform the Operation in the Spring Just as Growth Is Starting. Life activities promoting union and healing begin as the buds are opening. However, the operation may be performed a few weeks earlier, or if the cions are kept dormant, a few weeks later.

Kinds of Trees to Cleft Graft. Apple and pear trees may be cleft grafted easily. Plum and cherry trees are a little more difficult to graft as a rule. The bark of the sweet cherry tends to run in rings around the tree and must be cut ahead of the cleft. The wood of the peach is too soft for cleft grafting. If necessary to top-work the peach, it may best be done by budding some of the small shoots. Mature grape vines may also be cleft grafted.

Procedure and Factors:

- (*a*) Selecting equipment.
- (*b*) Selecting cions.
- (*c*) Making the cleft.
- (*d*) Preparing the cions.
- (*e*) Inserting the cions.
- (*f*) Modifications of procedure.
- (*g*) Subsequent treatment of cions.
- (*h*) Cleft grafting grape vines.

(*a*) *Selecting Equipment.* A sharp knife with a straight blade, a grafting chisel, a wood mallet for driving in the chisel to make the wedge or cleft, a pruning saw with teeth fine enough so that it will not tear the bark at the edges of the cut, and wax are the items needed in addition to the cions. A chisel with a curved handle to hang over the branches when not in use, and a mallet with a thong to slip over the wrist or a spur on the tree will eliminate trips to the ground to pick up fallen tools. All supplies may be carried in a basket equipped with a hook for hanging on the branches. A wood mallet is necessary because the chisel would break under the blows of an iron or steel hammer.

(*b*) *Selecting Cions.* For cions take wood of the previous season's growth. This will be the terminal growths or shoots from trees of the variety desired. Take them from bearing trees, if possible, to be sure of the variety. Use only well-developed buds on mature wood. The extreme tips formed late the previous season are usually soft with poor buds and should be discarded. Suckers, water sprouts, or young adventitious growths will do if the wood is mature and the buds well developed.

Store the cions in a cool, moist place where they will remain dormant until used. Place them in moist sawdust, sand, or moss, or roll them in a moist cloth. Do not keep them soaked with water, as this softens the bark and may cause them to decay. A favorite storage place on farms has been in the sawdust on top of the ice pack in the ice house. Cions cut early may be buried in a dry sandy knoll out of doors.

If the grafting is done while the trees are entirely dormant, the cions may be cut as needed. Cions that show injury from cold, indicated by a browning of the tissue beneath the bark, should not be used.

(*c*) *Making the Cleft.* Select a smooth area on the branch or stock, free from knots, where the grain is straight, and saw off the stock just beyond this point. In placing the chisel to make the cleft, put it in such a position that the cions when inserted will be in a horizontal rather than a vertical plane. If the cleft is vertical, the lower cion will grow up directly into the one above. This of course does not apply to grafting in the trunk.

Make the cleft with the chisel and mallet from 2 to 4 inches deep, starting the cleft carefully and cutting the bark with the knife ahead of the split or check if it does not part evenly.

Reverse the chisel; insert the wedge in the center of the split stock so that when the handle is pressed down the cleft will open to receive the cions.

(*d*) *Preparing the Cions.* Cut off a piece from the cion

(*Md. Exp. Sta.*)

FIG. 140. A good selection of branches for grafting was made on this tree. The grafts are beginning to grow. Two or three of the remaining branches may be grafted the following spring; the others will be cut off. Compare with Fig. 141.

wood carrying strong buds. The common number of buds on the cion is three, though this may be reduced if the cion wood is scarce or especially valuable. Cut off the cion just above the top bud.

Beginning at the base of the lower bud, with a straight, even stroke of the knife form a wedge with even sides and slightly thicker on the outside than on the side which is to be placed toward the center of the stock. Do not make the wedge too long; from 1 to 2 inches is sufficient. Make it blunt at the lower end, since if it is drawn to a fine point the bark may loosen from it when inserted in the cleft. With experience, two strokes of the knife will prepare the cion for insertion.

(*e*) *Inserting the Cions.* Press down on the handle of the chisel to open the cleft, and slip in the cion at the outer edge in such a way that the cambium or growing tissue of the cion is in contact with the cambium of the stock. This area is just beneath the inner bark and, since the bark on the stock will be thicker than that of the young cion, it is best to tilt the cion slightly outward at the top to insure contact.

(*Md. Exp. Sta.*)

Fig. 141. Too much of the original top remains in this tree. The grafts will be shaded too much and their growth will be weak. Compare with Fig. 140.

Slip the cion downward until the lower bud is close to the cut surface of the stock. Growth is more active at the buds, and union will take place sooner than if there is no bud at this point.

Since no growth may occur except at the point of junction of the cambium tissues of cion and stock, it at once becomes evident why the inner side of the wedge of the cion must be thinner than the outer side. If the reverse were true the cambium areas would be held apart and growth would be impossible The desirability of straight, even cuts on the ion also becomes evident in order to put the greatest possible areas of cambium in contact with each other.

If the stock is 2 or more inches in diameter, insert another cion in the same manner in the cleft on the opposite side. It is evident that the wedges on both cions must be of about the same size and design in order that both may fit well in the same cleft.

Release the pressure on the chisel handle and withdraw the chisel. The pressure of the stock will clamp the cions firmly in place. Wax all cut and exposed surfaces carefully to prevent drying out of the wounds and the entrance of moisture, insects, or disease organisms. Information on waxes is given in this chapter under "Grafting Preparations."

(*f*) *Modifications of Procedure.* If the branch to be grafted is extra large, two clefts may be made at right angles to each other and four grafts inserted, in order to hasten healing of the wound. It may be better to resort to inlay or bark grafting in such circumstances. In some cases the pressure or spring of the stock may be so great as to crush the cions. Relieve the pressure, in part, by placing a wedge in the center of the stock. The cions, however, must carry enough pressure to hold them firmly in place.

In grafting over a young tree only two or three years set, the branches of which are too small to take the cions, the trunk may be cut off at the desired point and one or more cions inserted directly into it (Fig. 142).

(*g*) *Subsequent Treatment of Cions.* Permit both cions to grow for several years (Fig. 143). Usually only one cion should be left to form a permanent branch. If both are left, a bad fork or crotch may result. However, both cions should be left for a time to hasten the healing process. After the first year the cion which is to be removed eventually may be gradually repressed through pruning, so that it may not interfere with the development of the other. After a period of years it should be entirely removed.

Prune the permanent graft just as would be done with any branches, keeping in mind that it will require some heading of

Fig. 142. (*a*) Cleft grafts inserted in the trunk of a tree which had grown three years in the orchard. (*b*) The same tree as the grafts are beginning their second season of growth. Each shoot grew more than 4 feet. Both grafts should be left for the present, but all shoots should be headed back quite heavily, with the exception of one of the center shoots. This should be headed lightly to encourage development of the scaffold branches.

the central or major shoot to induce a lateral growth as near the ground as possible.

If it is desirable to get some fruit quickly to test the variety, or for other reasons, prune as little as possible until fruit is

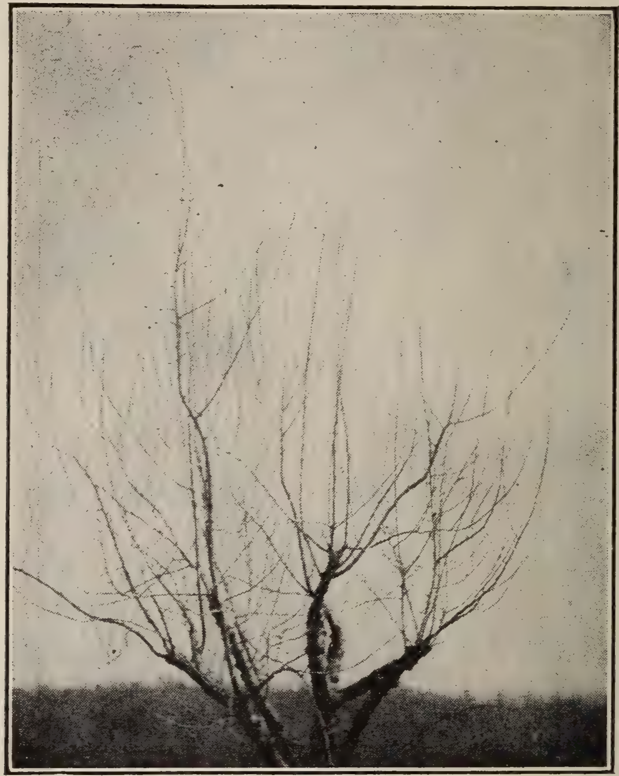


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FIG. 143. This grafted top has been growing three years and is making a good head. The upright shoot at the left should be topped lightly to encourage branching.

borne. Grafts frequently bear some fruit the third season and occasionally the second season.

Young grafts are particularly attractive to plant lice by reason of their quick, succulent growth. Special care should be exercised to keep them free in the early stages of their development. Thin out the suckers that develop around them during the season.

The grafts must be given plenty of sunlight if they are to thrive. On large trees some branches of the parent stock must be left for a time, but the tree should be completely reworked as soon as possible and all surplus branches removed.

Inspect the grafts frequently during the first season to make certain that all cut surfaces remain coated with wax. Another coating at the beginning of the second season is advisable in case of large stocks.

(*h*) *Cleft Grafting Grape Vines.* Grape vines already established in the vineyard may be cleft grafted to other varieties. Do the work in the spring before the sap has begun to move upward, or if this is not possible, wait until the first flush of sap is over. Keep the cions dormant until used.

Shovel away the soil about the base of the trunk and saw the trunk off about 2 inches below ground level. Since the grape trunk will not split readily, saw a slot with a fine hacksaw, about 1½ inches deep, and pry it apart to receive the cion.

Prepare the cion just as for the tree fruits, and insert in the same manner. If the size of the stock permits, insert two cions. Tie with a few turns of soft strong twine. Do not cover the union with wax or other preparation as air seems essential to healing.

Mound the soil up loosely about the cion, leaving one or two buds exposed. If the mound becomes hard, or if it forms in clods, remove it and hill over again as often as may be necessary to keep a loose, open covering permitting the entrance of air and the escape of moisture from the wound.

Keep suckers off the stock. Unless roots are desired on the cion, it will be necessary to hoe the soil away each year for two or three years and remove with a close clean cut any roots that may have formed on the cion below ground.

Vines grafted in this manner should fruit extensively the third season.

2. Inlay or Bark Grafting. For working over trees the branches of which are of considerable size, inlay or bark grafting is more easily performed than cleft grafting. The operation is performed at the same time of year as cleft grafting.

Equipment. A sharp knife, saw, tack hammer, brads or wire nails (No. 20, ¾-inch), and grafting wax are necessary.

Preparing the Stock. Select the branches in the same manner as for cleft grafting. It is not so necessary that the stock be free from knots as no cleft is made in it, but smooth places should be available on the bark (Fig. 144).

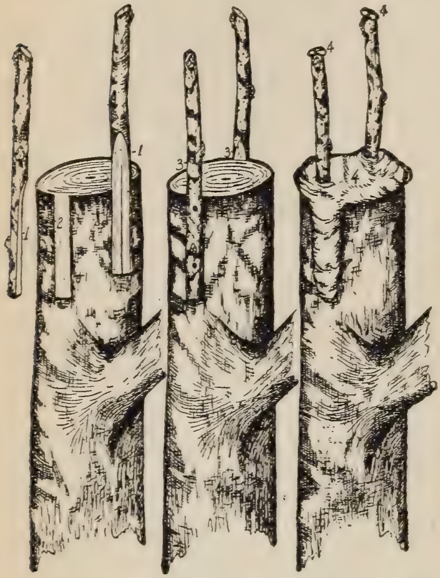

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FIG. 144. Inlay or bark grafting. (1) Cions prepared for attachment to the stock. (2) Stock prepared for cions. (3) Cions fastened in place with small nails. (4) All exposed parts waxed.

Preparing the Cion. Take cion wood in the same manner as for cleft grafting, preferably of large size so long as the buds are good. Cut in pieces, carrying three or four buds and about 4 inches long. At about the middle of the cion make an abrupt cut to the center on one side, turn the blade, and cut straight to the lower end. This will remove a section of the cion and leave a cut surface that is even and smooth. Make the cut on the side opposite the lower bud so that the bud may be retained and may function when the cion is in place.

Inserting the Cion. Place the cut surface of the cion lightly against the bark of the stock where the union is to be made, and trace the outline of the cion with the knife point. Remove the cion and take out the corresponding piece of bark on the stock. If growth is just beginning, the piece will peel out readily, leaving the growth or cambium cells exposed. If the inner bark adheres, remove it carefully.

Fit the cut surface of the cion against the exposed surface of the stock, and draw them together tightly by driving two nails carefully through the cion into the stock. Wax all cut and exposed surfaces carefully.

Insert two or more cions, depending upon the size of the stock. The more cions that are used, the quicker the healing process will be completed. Very large branches or trunks may be grafted, though the grafts are more likely to break out at some future time.

Subsequent treatment of cions is the same as in cleft grafting.

3. Whip Grafting. Whip grafting, or tongue grafting, as it is sometimes called, is used for parts too small to be cleft grafted.

The nurseryman uses it to establish known varieties on seedling roots. The fruit grower uses it to graft the trunks of small trees either after planting or later, and to change the tops of young trees by working over the branches to the variety desired. To use on trees, perform the operation just as growth is about to start in the spring, continuing if necessary for ten days or two weeks after growth has begun, provided that the cions are held in a dormant condition.

Equipment. A sharp knife with a thin straight blade is an essential. To this add grafting wax and waxed cord prepared as indicated under "Grafting Preparations."

Preparing the Stock. Select a smooth, clear place on the trunk or branch and sever the part with a clean, drawing motion of the knife, exposing a sloping surface 1 to 2 inches long (Fig. 145). Start the knife just above the center and cut toward the center and through it, working the knife downward against the grain to prevent splitting and making an incision about 1½ inches deep. This action prepares the tongue.

Preparing the Cion. Take the cion, selected and kept as for cleft grafting, and sever a piece bearing a number of buds and usually 4 to 6 inches long. Make a long, even sloping cut just as in case of the stock, and complete the tongue in the

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FIG. 145. Whip grafting. (1) Cion and stock prepared for union by diagonal cuts. (2) The tongue, made by starting the cut above the center. (3) Cion and stock united, with cambium layers in contact on one side. (4) Waxed string aids in holding cion and stock firmly in place. (5) All exposed surfaces thoroughly waxed.

same manner. Make the tongue on the proper end of the cion so that when the cion is in place the buds will grow away from rather than toward the stock.

Uniting Stock and Cion. Slip the tongue of the cion inside the tongue of the stock until the cion is firmly in place. Disregard one side of the cut surface of the cion, but make certain that the cambium of the other side is in contact with the cambium of the stock. It is seldom that cion and stock will be of the same size. In the effort to match up both sides, there is danger of missing cambium contact altogether; it is therefore better to confine attention to but one margin of the cut surfaces.

When the cion is in place, wind the place of union with waxed string without tying and without attempting to cover the entire union with cord. Wax all cut surfaces thoroughly, exercising care not to disturb the cion in the slightest degree.

Subsequent Treatment. After union and growth take place, cut the waxed cord to prevent girdling, unless the cord pulls apart itself.

Several or all of the buds on the cion may grow. Rub or cut off those that are not desired and train the top or branch in the usual manner.

Whip Grafting in the Nursery. As indicated in Chapter III, "Establishing the Orchard," the nurseryman employs whip grafting on the roots to establish the desired variety on the roots of the seedling. Whole roots or pieces of roots are used as stock. The operation is usually performed in February, following the same procedure as in grafting parts above ground. The union is bound with waxed cord, but is not covered with wax. The completed grafts are stored in bundles of 25 or 50 in moist sand in a cool cellar until spring.

A development of healing tissue about the union, termed a callus, takes place in the meantime. The grafts are planted about 6 inches apart in the nursery row and deeply enough so that only the upper bud appears above ground. One shoot is permitted to grow to form the tree. At the end of the season it is a one-year-old whip and may be sold as such, or it may be headed back to develop side branches and retained another year in the nursery row, being sold as a two-year-old tree.

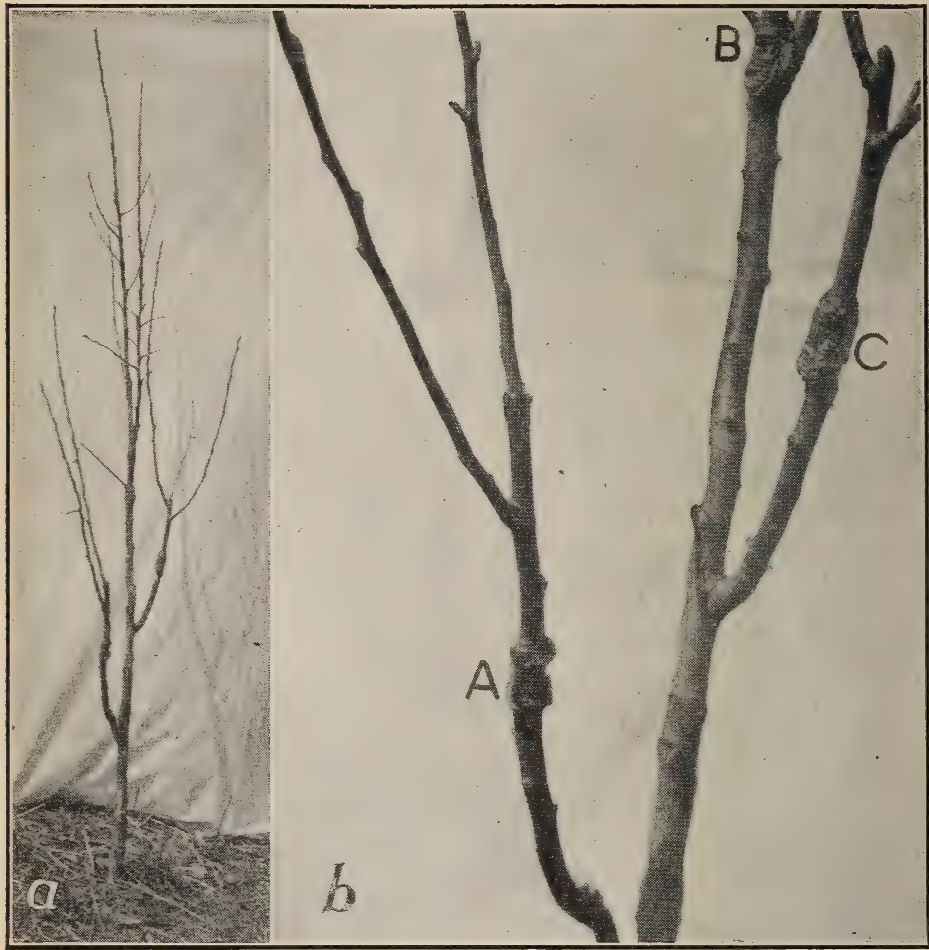

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Fig. 146. Whip grafting young orchard trees. (*a*) Whip grafts after one season's growth. (*b*) *A*, the waxed string was not removed at the proper time resulting in a weak union and partial girdling. *B* and *C*, good unions. The side branches above *B* hasten the healing process.

Own rooted trees are trees that have been grafted onto pieces of roots, using an unusually long cion. The graft is set deeply enough so that roots develop from the lower buds of the cion. When the tree is taken up from the nursery, the seedling root piece is removed and the tree is thus on its own roots.

Grapes are also bench grafted or tongue grafted in the dormant season.

4. Shield Budding. On young trees and those with small branches, budding is very useful in changing the variety. It is employed by the nurseryman to establish the desired variety on seedling stock. It is employed by the fruit grower to work over young trees, on either the trunk or the branches. The essential considerations are the same as in graftage, except that a single bud is substituted for the cion. The most common form is shield budding, taking its name from the shape of the bit of bark cut off with the bud.

Time of Performing Operation. The bark on normal fruit trees peels or slips in late summer. The trees are then ready to bud. The actual time varies with the fruit, the season, and the section. Ordinarily it occurs in August or early September.

Selecting the Buds. Take well-developed buds from the terminal growths of the current season on trees of the desired variety. Shoots so taken are termed bud sticks. Clip off the leaves immediately to stop evaporation, but allow part of the leaf stalks to remain attached to the buds to serve as handles in manipulating them (Fig. 147). Use the bud sticks at once or, if that is impossible, put them in a cool, moist place.

Top-Working by Budding. Buds may be inserted in the trunk if the tree is small. The top will be formed at some point above the insertion of the bud, and it is well to keep this in mind in selecting the place on the stock.

It is more common practice to bud the main branches, usually on the upper side not far from the point of union with the trunk, at the close of the first season's growth in the orchard (Fig. 148).

Select a smooth place on the stock and make a T-shaped slit through the bark (Fig. 149). If the bark is in good condition to work, the flaps will loosen and turn up on the points. Work the corners loose carefully.

Inserting the Bud. With a thin-bladed knife, cut a bud

(*Md. Exp. Sta.*)

FIG. 147. Bud sticks. (*A*) Before preparation. (*B*) Ready for the budding process.

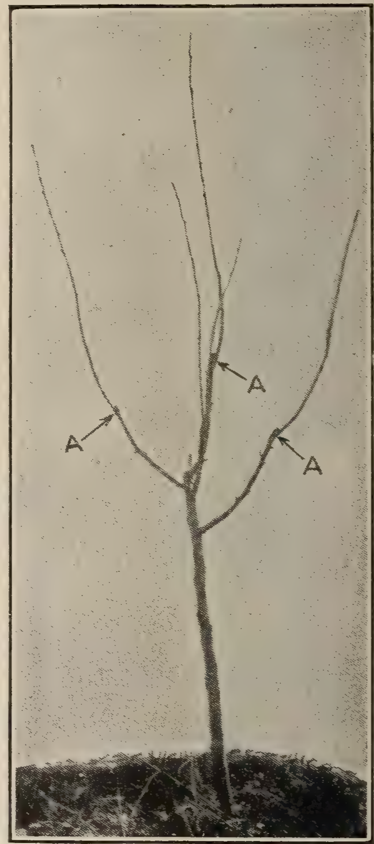

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FIG. 148. This Stayman Winesap apple tree was budded in the scaffold branches at *A* after one season's growth in the orchard. One year's growth has been made by the buds.

from the bud stick with a shield-shaped piece of bark and a very thin layer of wood under it. Slip the bud by means of the leaf stalk handle under the loose flaps on the stock and shove it into position. Make certain that the bud goes in in such a direction that it may grow outward or upward, and push it in far enough so that the bark of the stock completely envelops it.

The cambium tissues are thus together as in graftage. Tie the bud securely above and below with raffia. (Fine, soft cord or elastic will do.)

Subsequent Treatment. Inspect the bud in about two weeks. If union has taken place, cut the raffia on the side away from the bud to prevent girdling. If the union has failed, there may still be time to repeat the operation. If not, whip grafting may be employed the following spring.

The bud will remain dormant until the following spring. At that time cut off the stock above the bud. The bud will push out quickly into a vigorous shoot which may be trained to the desired form.

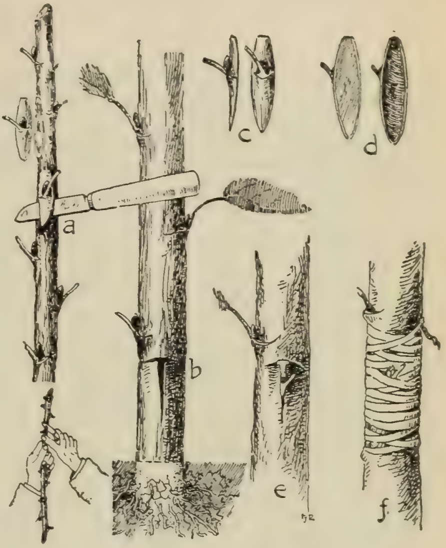

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FIG. 149. Shield budding. (*a*) Bud stick, method of holding stick and knife to cut bud shown below. (*b*) The incision on the stock. (*c* and *d*) Views of the bud. (*d*) At right shows wood removed, not necessary in ordinary budding of fruit trees. (*e*) The bud inserted. (*f*) The bud tied in place with raffia.

Top-Working Peach Trees. Peach trees in the orchard may best be worked over by budding. The wood of the peach is too soft and splits too readily to graft well. Cut back the top to force the development of new shoots near the base of the main branches. Bud these shoots in late summer.

Budding Nursery Trees. The nurseryman may use shield budding on his seedling stocks in late summer instead of whip grafting them (Fig. 150). In fact, the former is the more common practice at the present time and is the sole practice for peaches. The procedure is the same as outlined heretofore, except that the nurseryman buds the stock close to the ground. Trees showing a decided crook at ground level have been budded. The bud remains dormant until the following spring, when the stock is cut off above the bud.

In southern sections, budding of the peach may be done in June and is called June budding. The buds start growth at once, and the trees that develop from them are known as June buds. In such case, the stock above the bud is usually cut off a portion at a time, so as not to force the shoot from the bud too rapidly.

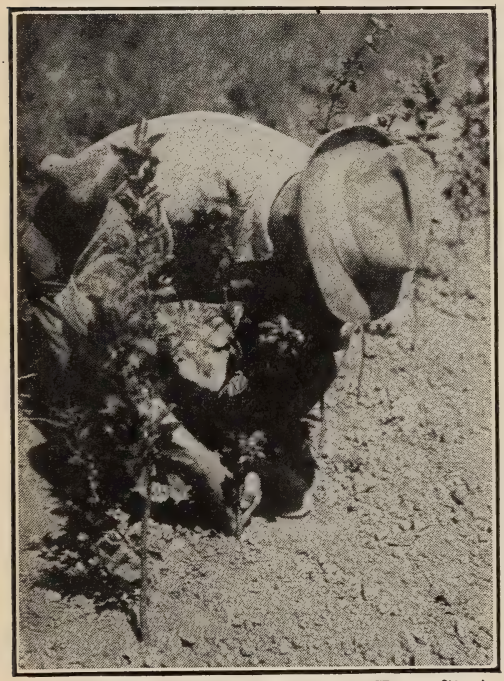

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Fig. 150. Budding seedling trees in the nursery.

5. Bridge Grafting. Trees are frequently girdled by mice or rabbits. Injuries to the trunk occur from implements or disease. These may cause the death of the trees, or seriously retard their development. If the trees are very young, it may be wiser to put new trees in their places than to attempt to save them.

Injury from mice and rabbits often occurs on trees of such a size and age that their death would mean a considerable loss. If such injuries are discovered in time and if they are not too extensive, the trees may be saved by bridge grafting. This operation is, as its name implies, a bridging of the gap between top and roots so that life functions and processes may go on. It is thus not a method of propagation, but is included here with other forms of grafting.

If the bark has been eaten from the roots for a considerable distance underground, as is sometimes done by the pine mouse, it will be difficult or impossible to perform the operation and save the tree. If the injury begins at, or a little below, ground level and extends up the trunk for greater or less distances, the operation is entirely feasible. It becomes more difficult as the area injured increases in width.

Seedling trees or nursery trees are sometimes set close to the injured trees and the tops grafted in above the wound. Watersprouts or suckers below the wound are also grafted in to bridge the gap. In trees set only two or three years these sprouts may be used to form a new top, provided that they spring from a point above that at which the tree was budded in the nursery.

Time of Performing Operation. Early spring following the injury, beginning when the buds are swelling and for two or three weeks thereafter is the best time to do the work. Go over the orchard well in advance carefully to determine the trees that need attention, so that the cions may be cut and kept dormant and fresh until used. Failures often result from doing the work too early or too late in the season.

Equipment. A sharp knife, tack hammer, brads 7/8 to 1 inch long (No. 18), and some form of grafting wax are needed. In addition, a light wood wedge to aid in bending the cions will prove useful.

Preparing the Cions. Use strong cions of the previous season's growth that have matured well. Mature watersprouts or suckers from hardy varieties are good. Do not use weak shoots. If good one-year cions cannot be found, substitute strong two-year growths. On large trees use the largest mature cions that it is possible to secure. For grafting on the roots, a cion with a curve at the base will be useful.

Determine the width of the space to be bridged (Fig. 151). Make the cions from 3 to 4 inches longer than this space. At about 2 inches from each end of the cion, make a long, sloping cut to the heart or center and then to the end with edges parallel. The cuts on both ends must be in the same plane so that both may fit evenly against the stock when the cion is in place.

Preparing the Stock. Cut slits in the healthy bark of the stock at the upper and lower edges of the wound to fit the cion. Lay the cion against the bark to get the correct measurements. Take out the bark clean, exposing the cambium tissue beneath. The bark will separate readily on a warm day when growth is starting. If any of the bark adheres to the stock, take it off carefully with the knife, disturbing the cambium as little as possible.

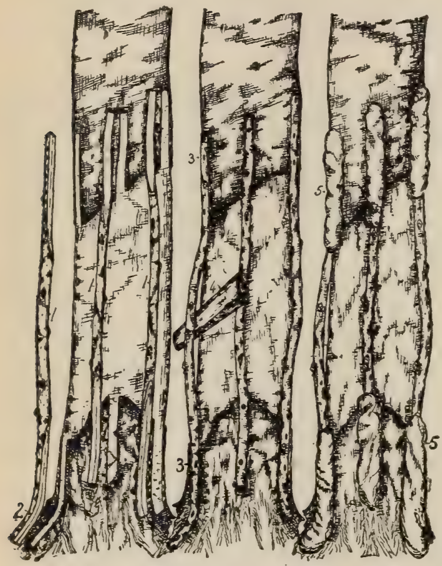

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Fig. 151. Bridge Grafting. (1) Cions ready for nailing. (2) A natural crook at the base of the cion works to advantage in grafting on a root. (3) The cions are drawn into place by small wire nails (1-inch, No. 18). (4) The cion is less likely to break away at the top if a wedge is used to give somewhat of a bow. (5) Wax all cut surfaces after the cions are set.

Inserting the Cions. Place one end of the cion in the lower groove with the cut surfaces together. Fasten it in place by driving one or more brads carefully through it into the stock. Bend the center of the cion over a wedge about an inch in thickness to give a spring or bow that will keep the cion in place as the tree sways in the wind and also to permit enlargement in diameter of the cion. Press the cion in the groove at the top and nail fast. Remove the wedge.

Place cions about 2 inches apart about the tree over the girdled area. Wax the ends carefully on the under as well as outer surfaces where exposed. A coating of wax on the girdled portion will discourage borers and keep the margins of the wound from drying out.

Subsequent Treatment. Buds may start from the cions. Rub them off so that cions serve only as carriers. If some of the cions fail, replace them the following spring. The cions will gradually increase in diameter until they have closed the spaces between them.

Modifications of the Operation. Some growers merely loosen the bark of the stock and slip the cions under it, fastening them in place. This is more difficult to do than to remove a section of bark entirely and gives no better results.

(*U. S. D. A.*)

FIG. 152. A bridge graft after the cions had grown two years.

6. Propagating by Cuttings. The grape, gooseberry, currant, and blueberry may be propagated from cuttings. Take 8- to 10-inch hardwood cuttings of the grape, gooseberry, and currant in the fall, from vigorous mature wood of the current season's growth (Fig. 153). These cuttings may either be set in the nursery row, covered with a mulch to prevent freezing and thawing, or placed in bundles and buried in sandy knolls with the bottom end up. The butts of the cuttings receive the heat from the late fall and early spring sun, which induces the formation of a callus or coating of tissue over them. The cuttings may also be stored in sand in a cool cellar and kept just moist enough to prevent drying out. Cuttings also may be made in early spring, but they will not give as high a percentage of rooted plants.

In the spring place the cuttings 3 to 6 inches apart in the nursery row, leaving not more than two buds above ground. They will be ready for removal to the field at the end of one or two years. If they are kept in the nursery for two years, it is good practice to transplant them at the beginning of the second

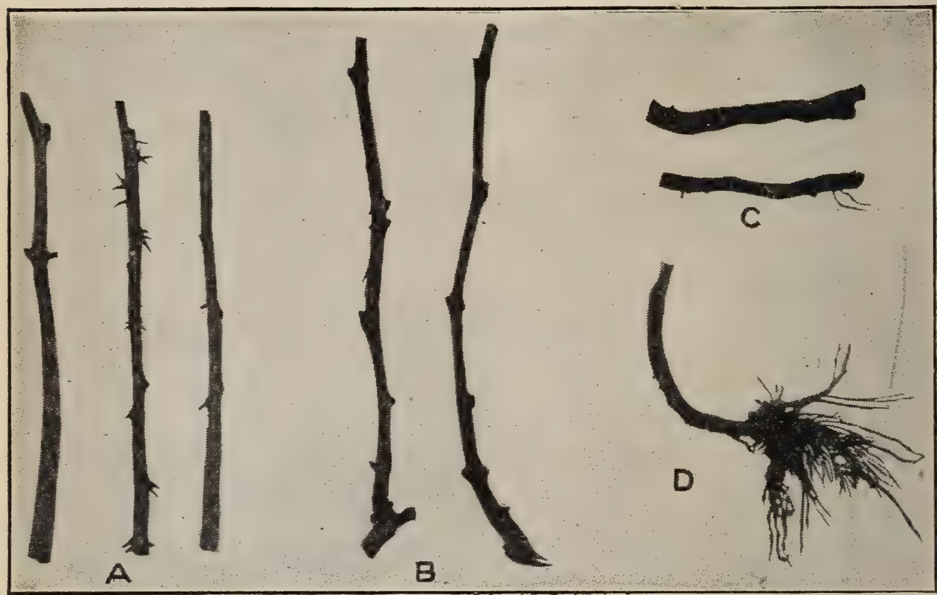

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Fig. 153. (*A*) Straight hardwood cuttings of grape, gooseberry, and currant. (*B*) Mallet and heel cuttings of grape. (*C*) Root cuttings of blackberry. (*D*) Tip layer of blackcap raspberry.

season. This gives the plants a close, compact root system that will be little affected by removal to the field.

As a rule, roots arise most readily from a node, or bud. In preparing cuttings make the lower cut just below a bud. Cut off the upper end far enough above the bud to prevent drying out. The mallet and heel cuttings as shown in Fig. 153B are also used for propagating some varieties of grapes which do not root readily from straight cuttings.

Root cuttings (Fig. 153C) are employed in propagating some varieties of blackberries and purple raspberries which do not sucker freely. In the fall, cut off pieces of the roots about 3 to 5 inches long and store in sand until spring, as previously indicated. The root cuttings develop both tops and roots from adventitious buds after the cuttings have been planted.

Blueberries may be propagated by softwood cuttings which should be taken in August. Cuttings are made about 4 inches long, and all the leaves except the upper two are removed (Fig. 154).

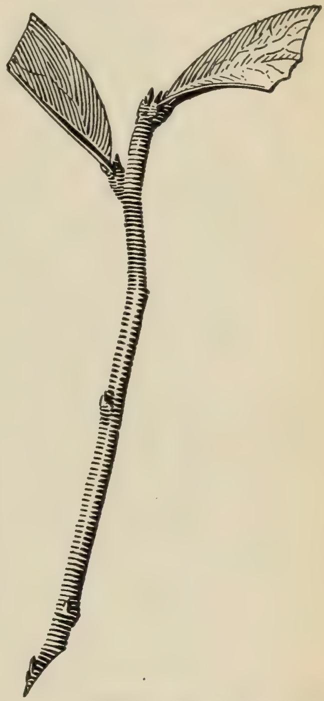

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Fig. 154. A softwood blueberry cutting ready for placement in the cutting bed.

Either a solar or box frame is a satisfactory propagating case. The former operates on the principle of supplying bottom heat, which is a decided advantage, but it is doubtful whether this will compensate for the extra cost of construction. Both types hold movable trays which are 4 inches deep and have a hardware cloth bottom. Further information may be obtained from the Michigan Experiment Station.

German peat moss is the most satisfactory rooting medium. Growth-promoting substances are believed to increase initial root development. The cuttings are placed in a slanting position, in a 4-inch layer of loose but firm damp moss. They are watered and the frame is covered with a burlap shading which is held 6 inches from the glass. Very little watering is necessary to keep the cuttings quite moist. Ventilation is very gradual and is practiced only after rooting has taken place.

In the fall the plants should be hardened off so that they will drop their leaves. It is well to store the tray in a cool cellar for the winter. The plants may be given a permanent position in the field in the spring.

7. Propagating by Layers. Plants which do not propagate readily by means of cuttings may sometimes be increased readily by layerage. Layerage consists of the formation of roots from a portion of the stem, but differs from cuttings in that the roots and stems of the new plant are formed while it is still attached to the old plant. The black raspberry cane bends over as it attains full length, and the tip, if covered with earth, roots readily and forms a new plant at that point (Fig. 153D).

Where the canes are long and can be laid over on the ground, as in the grape, the covering of the nodes at various points on the cane results in the production of roots at the nodes. Several new plants are thus secured from one cane. The new plants may be severed from the parent just as soon as the roots are well formed. This is usually done the following spring when the plants are put in the field or nursery row. Leave a portion of the old cane attached to each root to facilitate handling. New canes develop from the buds which form at the crown of the new plant.

Mound layerage is another method in addition to the use of cuttings for propagating the gooseberry; it is also used with the quince and Paradise apple. Cutting back the plants close to the ground in the spring, leaving a few buds on each stem, results in the production of vigorous new shoots. In June these shoots are mounded up with earth high enough to cover the lower buds, the soil being worked in well about them. Roots develop from the nodes. If sufficient growth has been made by the following fall, the earth may be removed and the new plants cut off and stored until spring, or they may be planted in the field at once in southern sections.

In the North, leave the plants attached until spring before severing them. It may be necessary to leave them attached through a second season.

The process may be repeated on the old plants from time to time.

8. Grafting Preparations. Several kinds of grafting wax are used in covering the grafts. Most of these waxes soften with heat, the soft wax becoming pliable at the temperature of the hand. Many formulas substitute ounces or pounds for parts, depending on the quantity to be made.

FORMULA FOR SOFT WAX

Resin (finely broken)	4 parts
Beeswax	2 parts
Tallow	1 part

Melt the tallow first, then add beeswax, and when this is melted, add the resin. Boil slowly for 30 minutes with occasional stirring; then pour the melted wax into cold water. Grease the hands, remove the wax, and work it by pulling it until it becomes straw colored and smooth grained. Twist in skeins and wrap in oiled paper. It may be kept for long periods. Grease the hands before applying the wax.

A brush wax, which does away with the inconvenience of handling the sticky hand wax, is made as follows:

BRUSH WAX

Beeswax	1 part
Resin	5 parts
Raw linseed oil	¼ part
Lampblack or powdered charcoal	½ part

Melt the beeswax, add and melt the resin, then add the linseed oil. Remove the mixture from the fire and stir in the lampblack a little at a time, to avoid boiling over.

As soon as cooking is completed, the wax may be partially cooled to a point where it flows slowly but easily and can then be used at once. The orchardist should make up a supply in advance, however, pouring the wax into shallow pans and allowing it to cool and harden. It is necessary to heat this mixture again for use. Apply with a brush or ladle.

Alcoholic wax is used in cold weather in order to avoid heating the wax in the field.

ALCOHOLIC WAX

Resin	16 parts
Tallow	1 part
Wood alcohol	8 parts

Melt the tallow, then add the pulverized resin and heat until entirely melted. Remove from the fire and stir until partially cooled, then gradually add the alcohol until the cooled mass has the consistency of paint. The wax will remain in this form until ready for use if placed in containers such as fruit jars and sealed to prevent evaporation.

Waxed String and Bandages. Immerse a ball of No. 18 knitting cotton in the hot, soft wax for about 5 minutes. Turn the ball frequently to insure complete saturation of the string. Remove the ball, suspend on a wire or stick, and turn it over several times while cooling to prevent the hot wax from settling in the lower side of the ball. Wrap in oiled paper until ready for use. Waxed bandages of muslin or cheesecloth may be prepared in the same manner.

GENERAL INFORMATION

Forms of grafting other than those described in this chapter may occasionally be useful. A form that is sometimes of value is the supporting of poor crotches through grafting cross-shoots from other branches at appropriate points on the branches. In such a case one end of the graft is already attached, and the other may be inlaid on the branch in need of support. The essential feature is to bring the cambium tissues in contact and to hold them there until union has taken place. The branches may need to be kept from spreading by tying or wiring until the graft has united. Small soft shoots from opposite branches may be twisted together and tied to serve the same purpose. They will soon grow together.

COMMUNITY STUDIES

1. Visit a nursery during February. Inspect the seedlings used for propagation. Note differences in size, length of root, and other characters of the seedlings.

Inspect cions used, and watch carefully the operation of root grafting.

2. Visit a nursery in August or early September. Watch the operation of shield budding. Inspect bud sticks and note especially the apparent vitality of the buds.

Are buds taken from bearing trees?

What precautions are taken to keep varieties from becoming mixed in the nursery rows?

Inspect root-grafted and shield-budded trees that have grown for a season in the nursery.

Note varietal differences in rate of growth and size.

Secure from the nurseryman information regarding the stocks used for the various fruits and the source from which they are obtained.

3. In late September, inspect shield-budded trees again. Note that the buds have set and the raffia has been cut. Why? Have the buds started to grow? What proportion of buds have "taken"? Does the proportion vary for the different fruits?

What proportion of budded trees make salable trees of first grade?

4. Visit some growers who have employed cleft grafting and whip grafting to work over trees. Under what conditions is each method employed? Note the distribution of the grafts through the trees. How long before the grafts begin to bear commercial crops?

5. Inspect some trees that have been bridge grafted, and note the procedure in detail. What proportion of the trees have lived and grown? What proportion of the grafts that were set? Are the bridge-grafted trees smaller in size than those not bridge grafted?

Find out from the fruit grower the time and expense involved in doing the work, and ask him for an estimate of the value of the trees that he has saved.

6. Perform, first in the laboratory and then on outdoor specimens, as many as possible of the operations described in this chapter. Prune and care for the grafts on the outdoor trees for a series of years.

7. Make some of the grafting preparations, including soft wax, and prepare the waxed cord.

CHAPTER VIII

POLLINATION AND FRUIT SETTING

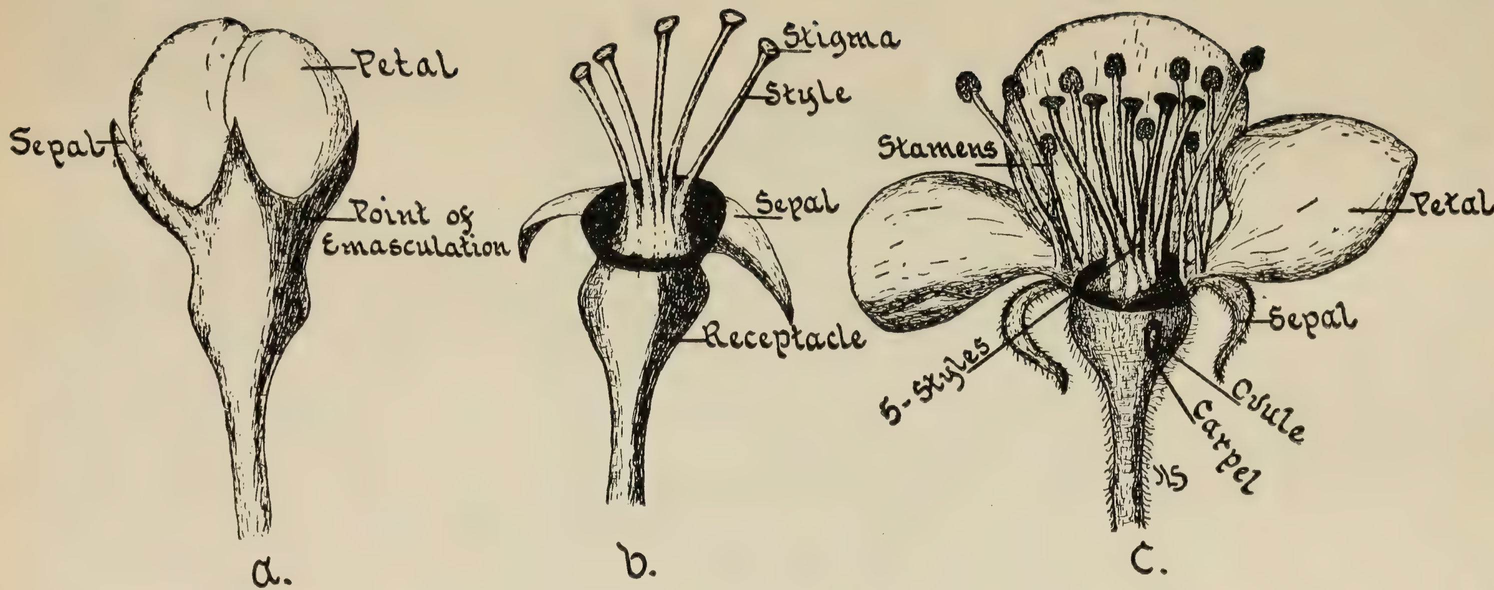
In many orchards the lack of proper pollination and fertilization of the blossoms results in poor crops of fruit. The blossoms of many varieties of fruit will not "set" with their own pollen. With such varieties even though weather conditions are satisfactory, poor crops of fruit will result unless provisions are made for cross-pollination.

In some of the older fruit sections where several varieties were often planted in the same orchard, little trouble has ever been experienced with the pollination problem, but in the newer and more recent plantings in the Southern and Western states, where solid blocks of one variety have often been planted, lack of proper pollination has frequently been one of the chief causes of poor yields.

Factors and Operations:

1. How pollination and fertilization take place.
2. Self-fruitful and self-unfruitful tree fruits.
3. Determining need for cross-pollination.
4. Reviewing the case.
5. Using bees in cross-pollination.
6. Treatment of established orchards in need of cross-pollination.

1. How Pollination and Fertilization Take Place. The blossoms of the tree fruits—apples, apricots, peaches, pears, plums, cherries, and quinces—considered in this book are hermaphroditic, that is, both stamens and pistils are present in the same flower. The calyx, composed of sepals, and the corolla, composed of the petals, are also present. The pistil



(*Col. Exp. Sta. Bul. 373.*)

FIG. 155. Drawings of a pear blossom. (*a*) Unopened blossom at proper stage for bagging for testing self-fruitfulness versus self-unfruitfulness. This is also the proper stage for emasculation (removal of male elements, the stamens). (*b*) Emasculated pear blossom. Its own source of pollen is now removed and pollen of any other variety can be placed on the stigmas in experimental work. (*c*) Longitudinal section of an open pear blossom showing all parts of the complete flower.

(female organ) consists of a stigma, style, and ovary, and the stamens (male organs) are made up of filaments and anthers (Fig. 155).

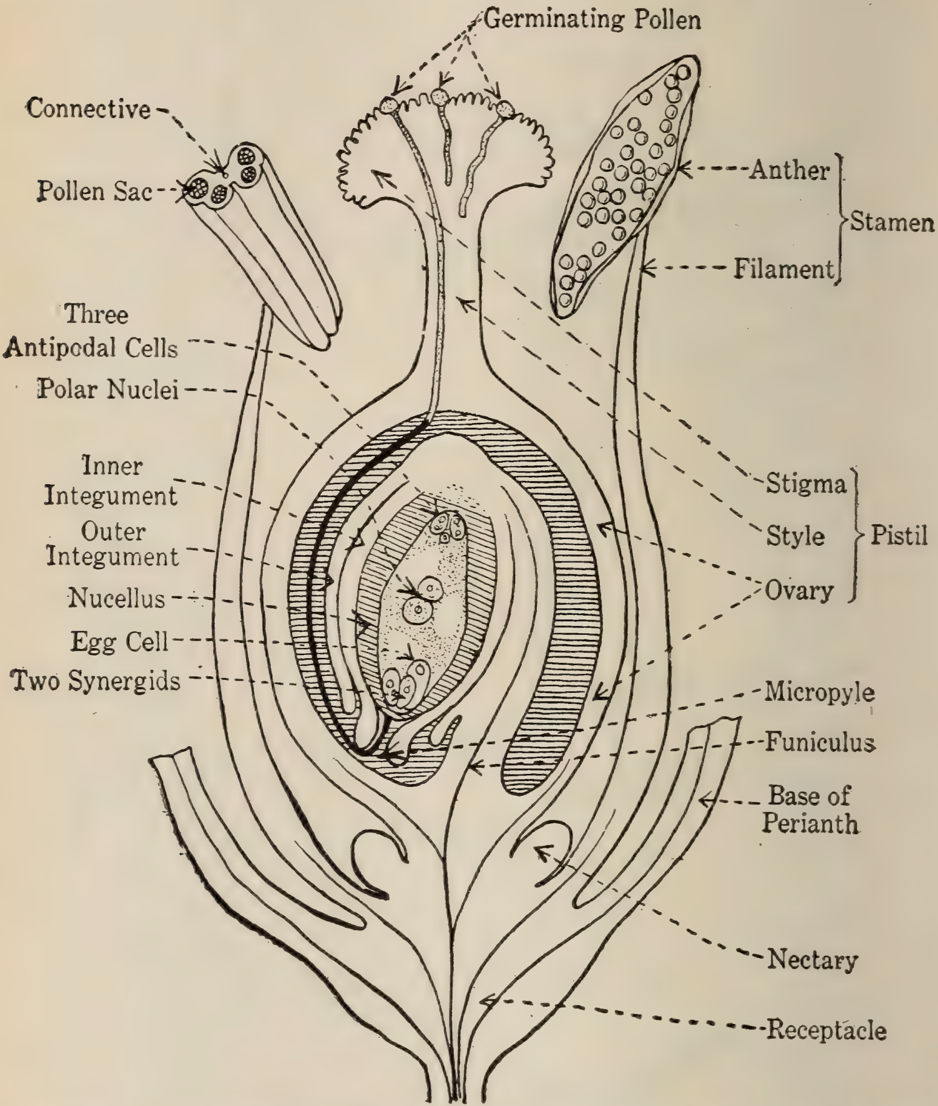
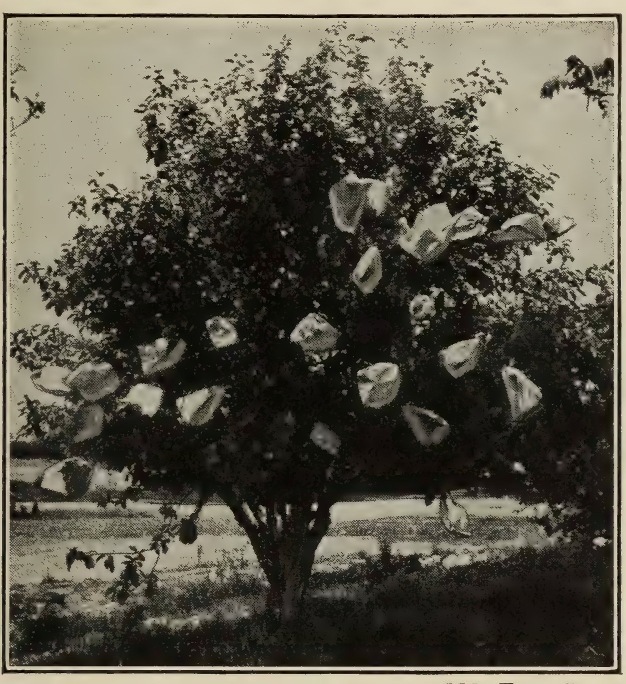


FIG. 156. Diagrammatic lengthwise section of a flower illustrating flower parts and pollen tube growth, resulting in fertilization of the egg cell and a set of fruit (*redrawn from Holman and Robbins.*)

The arrangement, number and structure of the different flower parts vary with the different fruits. For instance, in the cherry and peach only one stigma is present in each blossom, whereas five are found in the apple and pear.

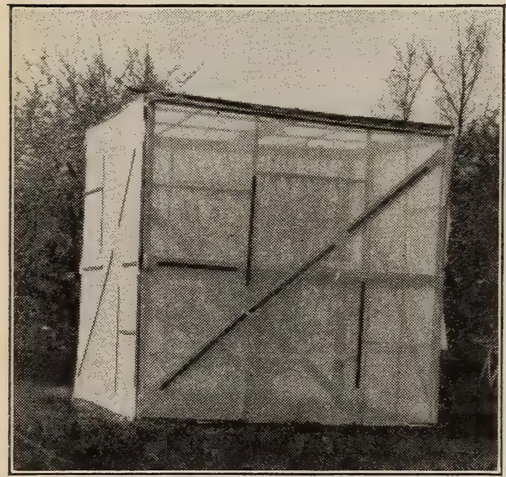
By *pollination* is meant the transfer of pollen from the anthers of the stamens to the stigmas of the pistils. In tree fruits, when the stigmas are pollinated with pollen from the same flower or from flowers of the same variety, the process is called *self-pollination*; when the pollen is transferred from the stamens of a different variety, *cross-pollination* is said to have occurred.



(*Md. Exp. Sta.*)

Fig. 157. Apple blossoms covered with paper bags in pollination experiments.

Pollination is generally followed rather quickly by germination of the pollen grain (Fig. 156). Water and possibly nutrients are absorbed from the surface of the stigma, the grain swells, and a tube is forced out. The pollen tube grows down through the style, enters the ovule, or unfertilized seed, penetrates to the embryo sac, and discharges two male germs or gametes. One of the male gametes fuses with the egg cell (female gamete), and *fertilization* is said to have taken place. As soon as fertilization of the egg cell occurs, the embryo, ovary, and other adjoining tissues begin to develop, an increase in size occurs, and the blossom appears to have "set." If pollination and fertilization do not occur, the blossoms soon turn yellow, wither, and drop, either at the time the petals fall or shortly thereafter.



(*Md. Exp. Sta.*)

FIG. 158. By inclosing trees at blossoming time under muslin or cheese cloth tents to exclude insects, studies in cross and self-fruitfulness can be made.

Although pollination and fertilization are necessary for fruit setting, this does not mean that all blossoms which are fertilized develop into fruits. Owing to competition for water and nutrients, many of the blossoms fall. Some drop at the time of petal fall, some two or three weeks later, and some at the time of the "June drop." After fertilization, those blossoms which have the most seeds and which are borne on the most vigorous spurs, so that more water, nitrates, and elaborated foods are available, are the ones most likely to set.

2. Self-Fruitful and Self-Unfruitful Tree Fruits. Many varieties of apples, pears, cherries, and plums will not set fruit if the blossoms are pollinated with their own pollen, or with pollen taken from another tree of the same variety. Such varieties are said to be *self-unfruitful.* If the pollen of such varieties is viable, that is, capable of germination, and the egg cells are normal, the varieties are said to be *self-incompatible* also. When varieties do set fruit with their own pollen they are said to be *self-fruitful* and *self-compatible.* The term *self-fertile* is used if fruits with viable seeds are produced, following self-pollination, whereas the term *self-sterile* is employed if no viable seeds are produced when self-pollination occurs.

It can thus be seen that a variety may be both self-fruitful and self-fertile, or self-fruitful and self-sterile. Sometimes two varieties are found neither of which will fertilize the other. These are called *intersterile*.

When the above facts are known, it is apparent that if certain self-unfruitful and intersterile varieties are planted in large blocks, and in a section where there are no nearby orchards of other varieties, such varieties will bear practically no fruit, even though they may bloom profusely.

3. Determining Need of Cross-Pollination.

(*a*) Apples.
(*b*) Pears.
(*c*) Plums.
(*d*) Cherries.
(*e*) Peaches and apricots.
(*f*) Quinces.

(*a*) *Apples.* The following apple varieties appear to be self-unfruitful in most states where studies have been made, and should not be planted alone in solid blocks:

Group I

Akin	Roxbury Russet
Arkansas Black	Scarlet Pippin
Arkansas (Mammoth Black Twig)	Stark
	Starking
Cortland	Stayman Winesap
Delicious	Summer Rambo
Golden Delicious	Sweet Delicious
King David	Tompkins King
McIntosh	Twenty Ounce
Northern Spy	White Pearmain
Ohio Nonpareil	Williams
Opalescent	Winesap
Red June	Winter Banana
Red Spy	Wolf River
Rhode Island Greening	Yellow Bellflower

The following apple varieties have been reported by several investigators to be at least partly self-fruitful:

GROUP II

Baldwin	Oldenburg (Duchess)
Ben Davis	Red Astrachan
Cox Orange	Red Oldenburg
Early Harvest	Red Gravenstein
Esopus (Spitzenburg)	Red Rome
Gano	Rome Beauty
Gravenstein	Wagener
Grimes	Wealthy
Jonathan	Yellow Newtown
Maiden Blush	Yellow Transparent
Milton	York Imperial
Northwestern Greening	

With some the varieties in Group II a sufficient set has been secured in some orchards where the blossoms have been enclosed in bags to give a commercial crop of fruit. Field observations of large plantings of certain of these varieties also indicate that good crops will result from self-pollination if other conditions are satisfactory. This seems to be especially true of such varieties as Baldwin, Ben Davis, Grimes Golden, Oldenburg, Wealthy, Rome, Yellow Transparent, Yellow Newtown, and York Imperial. However, even with these varieties, better crops are generally secured where cross-pollination takes place. This is especially noticeable in cold, cloudy seasons unfavorable for pollination purposes.

Since cold, cloudy, and damp weather often occurs in many fruit sections, at least during part of the blossoming season, and since the set of fruit is often light in such years, with resultant high fruit prices, it is evident how important it may be to have additional pollenizers in the orchard to assist in securing a larger set of fruit.

As a rule, the pollen of one variety of apple will fertilize the blossom of another variety, provided that the blossoming periods of the two varieties overlap so as to make an abundance of pollen available at the proper time. This is not true, however, of a few varieties. Certain of the Winesap group of apples, such as Stayman Winesap, Arkansas (Mammoth Black Twig), and Winesap, are intersterile for all practical purposes. These varieties are thus not only self-unfruitful, but cross-unfruitful also, and it is necessary to plant other varieties with them such as Delicious, Jonathan, Grimes Golden, or Yellow Transparent, if satisfactory crops are to be had.

Although the pollen of the Grimes Golden is usually excellent to use as a pollenizer, still, when it is applied to Arkansas (Mammoth Black Twig) pistils, practically no fruit results. Growers should consult their experiment-station officials and secure the latest information relative to the cross-compatibility of the varieties which they wish to plant.

Poor Pollenizers. The results of experiments in various parts of the country indicate that certain varieties make very poor pollenizers. Stayman Winesap, Arkansas, and Winesap pollen appears to be defective and germinates very poorly under controlled conditions. As a result, these varieties should not be relied upon to fertilize any of the other varieties. Likewise the pollen of Baldwin, Rhode Island Greening, Gravenstein, Ohio Nonpareil, and Nero usually germinates poorly and causes poor sets of fruit when used on other varieties. Fruit growers should thus avoid these varieties when selecting a pollenizer.

Good Pollenizers. Some varieties seem to be unusually good pollenizers and generally cause excellent sets of fruit. In this group are found:

Cortland	Red June
Delicious	Rome Beauty
Golden Delicious	Steele Red
Grimes Golden (except for the Arkansas variety)	Wagener
	Wealthy
Jonathan	Winter Banana
McIntosh	Yellow Transparent
Northern Spy	York Imperial

(*b*) *Pears. Many Varieties of Pears Set Better Crops if Pollinated with Other Varieties.* In the Eastern sections of the United States, experiments and field observations indicate that the following varieties are either entirely self-unfruitful, or they are self-unfruitful to such a degree that satisfactory crops will not be produced unless they are pollinated with other varieties:

Anjou	Columbia	Mount Vernon
Boussock	Easter Beurre	Sheldon
Clairgeau	Howell	Superfin
Clapp's Favorite	Lawrence	Winter Nelis
	Kieffer	

In addition to the above varieties, the following varieties will set much better crops if cross-pollinated, although fair crops are occasionally produced with their own pollen:

Bartlett	Gorham
Buerre Bosc	Phelps
Cayuga	Souvenir du Congress
Ewart	

The following varieties set fair crops with their own pollen but no doubt would be benefited by cross-pollination:

Buffum	Manning
Duchess d'Angouleme	Seckel
Flemish Beauty	Tyson
LeConte	

So far as is known, practically all varieties of pears which bloom at the same time will cross successfully with each other.

(*c*) *Plums.* By far the largest percentage of Japanese plums (*Prunus salicina*) studied in this country are self-unfruitful and thus should not be planted in solid blocks. The following varieties are included in this list:

Abundance	El Dorado	Ogon
Apex	Engre	Prize
Burbank	Formosa	Satsuma
Chabot	Gaviota	Sultan
Combination	Kelsey	Upright
Duarte	Kerr	Wickson
	Maru	

The following varieties will set a limited amount of fruit in certain years with their own pollen, but set much better crops if pollen of other Japanese varieties is available for cross-pollination purposes.

Beauty	Methley
Climax	Santa Rosa

Practically all varieties of Japanese plums with the exception of Formosa and Gaviota are cross-fruitful.

Several of the European varieties of plums are self-unfruitful. The European species (*Prunus domestica* and *Prunus insititia*) do not have as high a percentage of self-unfruitful varieties as the Japanese and American species. Of those studied, the following are self-unfruitful for all practical purposes and should not be planted in solid blocks:

Bavay	Jefferson	Sergeant
Clyman	Imperial	Standard
German Prune	McLaughlin	Tragedy
Golden Drop	President	Washington
	Quackenboss	

The following varieties set fair crops with their own pollen:

Agen	Reine Claude
California Blue	Sugar
Giant	Victoria
Italian Prune	Yellow Egg

Certain other varieties set light crops with their own pollen in some years, but much better crops are produced if pollen of other varieties is available. This list includes Diamond Grand Duke, Pond, and Shropshire.

There seems to be practically no-cross-incompatibility between European varieties of plums; therefore satisfactory crops should be produced if any two varieties are interplanted, provided that their blossoming seasons overlap.

Practically all varieties of American species of plums that have been observed in pollination studies are self-unfruitful.

Most of them will intercross satisfactorily. Varieties of these species are of minor commercial importance in many regions.

Certain Plum Species Do Not Intercross Satisfactorily. Apparently varieties of the Japanese and American species are interfruitful, and these can be planted together if desired for cross-pollination purposes. The European species (*Prunus domestica* and *Prunus insititia*) likewise appear to be interfruitful. Varieties of *Prunus domestica* do not, for the most part, cross satisfactorily with those of the Japanese and American species.

(*d*) *Cherries.* The pollination problem with cherries depends upon whether sweet, sour, or Duke (crosses between sweet and sour) varieties are grown. Practically all varieties of sweet cherries are self-unfruitful. Provision should always be made for cross-pollination when planting a sweet cherry orchard. Most varieties produce plenty of viable pollen, but certain ones appear to be better pollenizers than others. Some varieties are intersterile. Thus, Napoleon, Bing, and Lambert, three very important commercial varieties on the Pacific Coast, will not fertilize each other. However, varieties such as Republican, Black Tartarian, Wood, Early Purple, Rockport, Windsor, and certain others pollinate these three varieties successfully.

Sour cherry varieties are self-fruitful in most sections. Experimental studies and field observations show that in many sections the common varieties of sour cherries such as Early Richmond, Montmorency, English Morello, Wragg, and Dyehouse are usually self-fruitful and will set good crops without cross-pollination. Reports from Oregon, however, indicate that several varieties, including the Montmorency, are self-unfruitful for all practical purposes under local conditions. So far as is known, varieties of sour cherries blossoming at the same time pollinate each other readily.

Many varieties of Duke cherries are self-unfruitful. Experimental evidence available in this country suggests that much better crops would result in all Duke varieties if at least two varieties are interplanted when planting the orchard.

Sweet, sour, and Duke cherry varieties vary as regards their interfruitfulness. Varieties of these three groups will intercross, but, as a rule, pollen of the Duke cherries does not cause as satisfactory a set on either sweet or sour cherries as pollen from varieties within their own groups. Pollen of sweet cherries will cause satisfactory sets on sour cherries, but as a rule the sweet cherries bloom too early to be satisfactory pollenizers for the sour. Sweet cherries will also fertilize the Dukes satisfactorily if their blossoming periods overlap. Likewise, pollen of the sour cherries will fertilize both the sweet and Duke cherries if their blossoming periods coincide. For early-blooming Dukes, sweet cherries should be satisfactory pollenizers, whereas sour cherries should be more satisfactory for the late-blooming varieties.

(*e*) *Peaches and Apricots.* With a few exceptions, all important peach varieties that have been studied have been found to be self-fruitful. The variety J. H. Hale, however, has been shown to be self-unfruitful and practically no crops are borne unless pollen from other varieties is available (Fig. 159). Likewise, the June Elberta appears to be self-unfruitful for all practical purposes, and the Late Crawford is usually benefited by cross-pollination. The pollen of almost any variety which blossoms at the same time as these varieties causes a good set.

All varieties of apricots tested, including Blenheim, Lewis, Montgamet, Moorpark, Royal, and Tilton, appear to be sufficiently self-fruitful to set commercial crops.

(*f*) *Quinces.* Although very little evidence has been secured relative to quince pollination, the data available indicate that the varieties commonly grown such as Champion, Orange, Meech, and Rea are sufficiently self-fruitful to set satisfactory crops with their own pollen.

4. Reviewing the Case. From the preceding discussions of fruit pollination and fertilization, it can be seen that, with the possible exceptions of sour cherries, quinces, some of the

European plums, and most peach varieties, provisions should be made for proper cross-pollination when planting the orchard. In addition to the self-unfruitful varieties, many, if not all, of

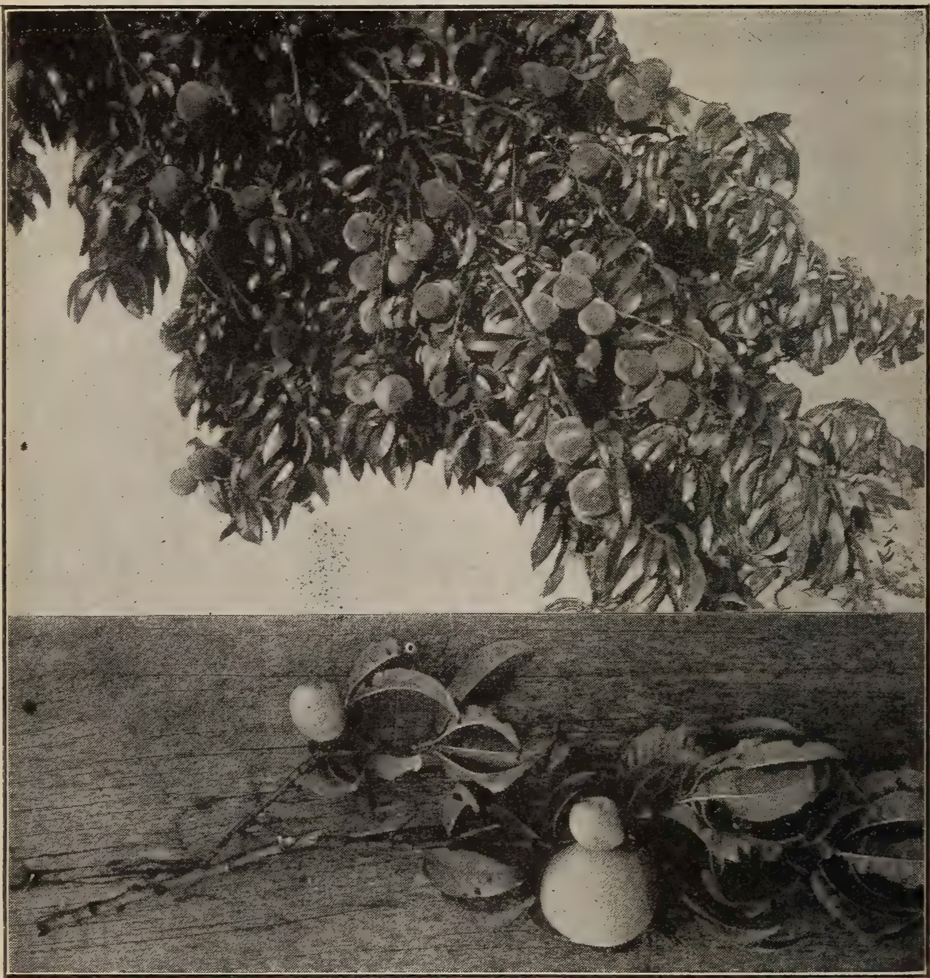


Fig. 159. Lower, a branch from J. H. Hale peach tree showing one normal fruit, the result of cross-pollination, and two "buttons" resulting from self-pollination. Upper, a branch from a tree of the same variety on which the fruit was cross-pollinated. (*Mich. Special Bul. 188.*)

the varieties of apples, pears, and plums which are listed as self-fruitful, or partly so, will usually be benefited by cross-pollination; at least, larger crops usually result and the June drop, especially in bad pollination years, is less.

Effect of Pollen on the Size, Shape, and Color of the Fruit. Fruits of the apple and pear which result from cross-pollination are often of better shape, size, and color than those resulting from self-pollination, but their shape and color are typical for the variety regardless of the kind of pollen used. For instance, the pollen of a yellow variety like Grimes does not cause yellow streaks to appear on red apples; neither does the pollen of a round apple change the shape of an oblong or flat apple. Fruits which are cross-pollinated generally have more seeds, appear to set and start into growth sooner, hang on better, and, because of increased vigor, generally are of better size and color at picking time. The better shape often encountered in crossed apples and pears is generally due to the fact that all cells contain seeds and thus develop normally. Seeds are often missing in some of the cells of self-pollinated fruits, and this generally results in lopsided or misshapen fruit.

Qualifications of a Good Pollenizer. Several factors should be considered when selecting a pollenizer for cross-pollination.

1. It is necessary first to be sure that the pollenizer selected produces plenty of viable pollen, and that it will cause a set of fruit on the variety to be pollinated. In other words, the varieties must be cross-compatible.

2. The blooming periods of the two varieties should overlap.

3. The pollenizer should come into bearing as early as the variety to be pollinated.

4. The pollenizer should be an annual bearer, if possible, or at least should produce some blossoms every year.

5. The pollenizer selected should, if possible, be desirable commercially. It should not be necessary to select some undesirable market variety just for pollination purposes. There are usually enough good market varieties which are also good pollenizers from which to make a selection.

Cortland is an excellent pollenizer for McIntosh; Rome will pollenize Northern Spy; Delicious and Wealthy will pollenize almost any varieties with overlapping blooming periods.

Determining the Number and Arrangement of Pollenizers in the Orchard. Not more than four rows of a self-unfruitful variety should be planted together. If two varieties are being planted in equal numbers, four rows of one and then four rows of another can be planted, although practical orchard observation indicates that two rows of one and then two rows of another often result in larger crops. Orchardists who have been studying this problem in the Shenandoah-Cumberland Valley section state that their best crops, especially in bad pollination years, occur where not more than two rows of the same variety are planted together. If more of one variety is desired than another, two or three rows to one, or four to one, can be planted.

If the least possible number of pollenizers is desired, there should be at least one pollenizing tree to every thirty trees in the orchard, or about every fifth tree in every fifth row. It would be much safer, however, to have at least one tree out of every nine a pollenizer. This would mean that every third tree in every third row should be a pollenizer.

Whenever two self-unfruitful varieties are planted together, only one of which is capable of pollinating the other, a third variety should be planted to pollinate the second one.

For instance, in the case of apples, if Delicious and Stayman Winesap were planted together, the Delicious would pollinate the Stayman Winesap satisfactorily, but since the Delicious is self-unfruitful, and since the Stayman Winesap pollen is of no value for fertilizing any variety, it can be seen that practically no fruit would be borne on the Delicious. Then a third variety, as Grimes or Jonathan, should be planted to pollinate the Delicious. On the other hand if Yellow Transparent and Stayman Winesap were planted together the Yellow Transparent would fertilize both the Stayman Winesap and itself, and satisfactory crops would probably be produced on both varieties.

5. Using Bees for Cross-Pollination. Bees are of great value for cross-pollination purposes, and unless wild bees are very common, every fruit grower should arrange to have colonies of bees evenly distributed throughout the orchard at blossoming time.

It has been shown by different investigators that pollen of several of our tree fruits is carried only short distances by the wind and that agency cannot be relied upon to effect satisfactory cross-pollination. No doubt wind, especially by shak-

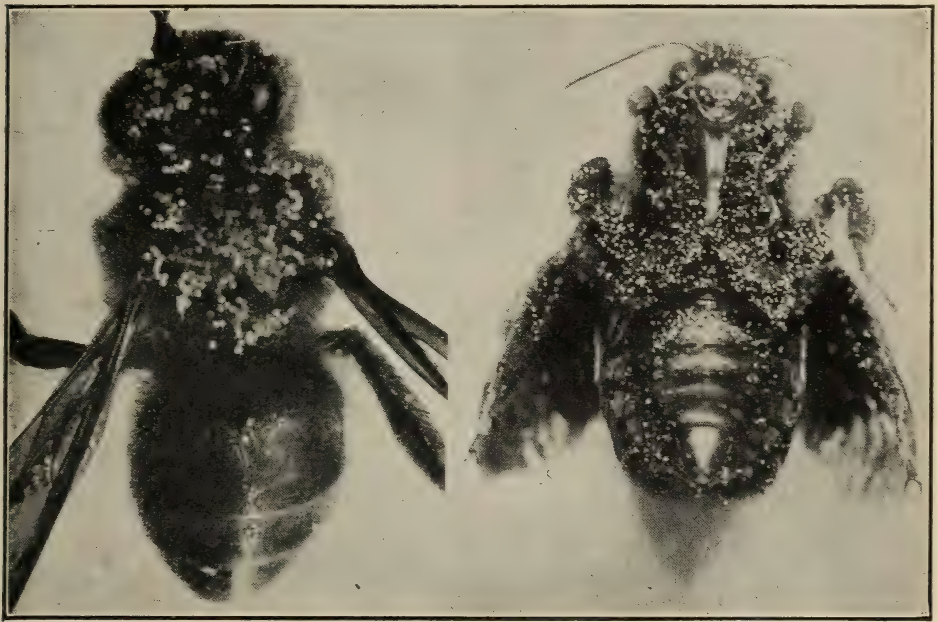


Fig. 160. Left, a honey bee with pollen grains on its body as a result of visiting blossoms; right, a bumble bee, showing pollen grains. (*Mich. Special Bul. 188. Photos by Cornelius Clarke, Grinnell, Iowa.*)

ing and jarring the limbs, aids in distributing the pollen from the anthers to the pistils of the same blossoms, however, and thus helps to cause better sets on self-fruitful varieties, especially in peaches and sour cherries.

Insects are the main agencies in effecting cross-pollination between varieties. In flying from blossom to blossom their bodies become covered with different varieties of pollen, and this is left on the different stigmas as they crowd down into the blossom to secure the nectar. Honey bees, because of their large numbers in many regions, play an important part in cross-pollination.

When two varieties of tree fruits are inclosed in a tent with a hive of bees, much better crops are borne than if the same varieties are inclosed in a tent without bees. It has also been clearly shown, for certain self-fruitful varieties of different tree fruits, that the set of fruit is greatly increased, even in such cases, if bees are present.

The value of bees in carrying pollen has also been strikingly shown, especially in bearing orchards of self-unfruitful varieties planted in solid blocks, by distributing colonies of bees in the orchard and then hanging blossoming branches of other varieties in buckets of water in some of the trees and by placing some of the branches near the hives. By carrying the fresh pollen of the different varieties from the blossoming branches to the blossoms of the tree, bees have caused satisfactory commercial crops to be produced in large orchards which previously had borne very little fruit, though blossoming freely each year. It is generally necessary to renew the blossoming branches once or twice during the blooming period so that plenty of fresh pollen will be available.

Kinds of Bees and Insects as Pollen Carriers. Although honey bees are very valuable as pollen carriers, still, in some regions, other insects, no doubt, aid greatly in cross-pollination. Bumble bees are considered to render great aid in certain of the New England states, and various flies are important aids in other sections.

Number of Hives Required. One colony of seven to nine pounds of bees to every three or four acres is a good investment, and many growers who realize the value of bees keep one colony to every one or two acres of orchard.

It is not merely a question of having some colonies of bees in the orchard. They should be healthy and vigorous. Most orchardists will prefer to rent colonies from an experienced beekeeper who will place colonies, care for them, and remove them. The rental charge varies from $3.00 to $5.00 for the blossoming season.

Distance Which Bees Will Carry Pollen. It is impossible to state definitely how far bees will fly and carry pollen. This will vary, of course, with several factors, such as kind of weather at blossoming time and the distance of the bloom from the hive. In warm, sunny weather, bees may fly long distances, and so self-unfruitful varieties, even in rather large blocks, may be satisfactorily pollinated even though other varieties may be at some distance. However, the value of bees, and of pollinating varieties, is especially shown in seasons when the weather is cold, damp, and windy, and when only occasional short periods are favorable for bee flight. In such seasons, when the set is generally poor, and the prices of fruit high at picking time, the great value of bees for cross-pollination purposes is clearly evident.

Length of Time to Keep Bees in the Orchards. It is necessary to have the bees in the orchard only during the blossoming period. As a result some growers place their own hives in the orchard during this period only, or rent hives during this time. Most growers remove their bees to other locations as soon as blossoming is over for the following reasons: (*a*) more food will be available for the bees, (*b*) there will be less danger of injury to the horses and workmen during the summer, (*c*) there will be less chance of the bees spreading fruit diseases such as brown rot of peaches and fire blight of pears, and (*d*) the possible damage to bees from the use of arsenical spray is eliminated.

6. Treatment of Established Orchards in Need of Cross-Pollination. As soon as a fruit grower learns that he has a self-unfruitful variety planted in a solid block, he should top-work one tree in nine (the third tree in every row) or at least one tree in thirty (the fifth tree in every fifth row) to a cross-compatible variety. In addition, he should place several hives of bees in the orchard and bring in blossoming branches of other varieties each year until the grafts are able to furnish sufficient pollen for cross-pollination purposes.

If the grafts are pruned lightly each year, enough blossoms are often produced during the third or at least the fourth year

Fig. 161. Lower, blossoming branches of a good pollenizer in buckets of water hung in the branches of a variety in need of cross-pollination. Upper, colonies of bees on their way to Michigan orchards for pollination purposes. (*Mich. Special Bul. 188.*)

so that it will not be necessary to continue to bring in the buckets of blossoming branches. It is very important, however, that plenty of bees be retained for distributing pollen from the grafts.

COMMUNITY STUDIES

1. Visit several orchards and determine whether any provisions have been made for cross-pollination between varieties.

2. Secure data on the date and length of the blooming period of several varieties of all tree fruits in the community.

3. From the data obtained from Study 2, determine what varieties would be suitable for cross-pollination purposes as far as the overlapping of their blooming periods is concerned.

4. Determine whether orchards consisting of several varieties "set" a higher percentage of their blossoms than orchards of one variety.

5. Which varieties of the different tree fruits appear to "set" the highest percentage of blossom, when planted in solid blocks?

6. Is the "set" of fruit as heavy in seasons when the weather is cold, rainy, and windy during blossoming time as when it is warm, quiet, and sunny?

7. Determine where beehives should be located in the orchard for cross-pollination purposes.

8. Remove the petals from a few apple blossoms before the petals open, and determine whether bees visit such blossoms when the showy attractive petals have been removed.

9. Place some paper bags over several blossoms of the different tree fruits just before the petals open, and remove the bags after the petals have fallen. Determine which varieties "set" fruit under the bags.

10. Collect and ripen pollen of several varieties of apples, emasculate a few blossoms of each variety, and make several different cross-pollinations. Determine later which crosses have resulted in the best set of fruit.

11. Collect blossoms of several different kinds of fruit. Study them carefully, make drawings, and label the different parts.

12. After the "June drop" determine whether there are more or less good seeds in the apples which have fallen compared to those still remaining on the tree.

13. Visit several orchards at blossoming time and determine the different insects that are visiting the blossoms.

14. What percentage of the blossoms "set" fruit in: (*a*) a well-cared-for, vigorous orchard, and (*b*) a poorly cared-for weak one?

CHAPTER IX

MANAGING ORCHARD SOILS AND FERTILIZING THE TREES

DIAGNOSING GROWTH CONDITIONS AND PRESCRIBING TREATMENT

To get satisfactory crops of fruit, good tree growth is necessary. The decision regarding the method of soil management and the kind and amount of fertilizer to use in an orchard should be based upon the ability of these procedures to produce desirable conditions of tree growth. The kind of soil management chosen affects both the kind and amount of fertilizer required.

Operations:

Managing Orchard Soils

1. Determining the system of apple-orchard culture to use.
2. Selecting the implements for soil management.
3. Determining culture of other tree fruits.

Fertilizing the Trees

1. Deciding whether fertilizers are needed for apple trees.
2. Deciding which fertilizers are needed.
3. Deciding how much fertilizer to use and when to apply it.
4. Applying the fertilizer.
5. Determining the cost of applying fertilizers.
6. Fertilizing other tree fruits.

Managing Orchard Soils

1. Determining the System of Apple-Orchard Culture to Use. In deciding which system of orchard soil management to use, the following factors should be taken into consideration:

(*a*) Consider the objects sought.
(*b*) Consider the different soil-management systems which might be used.
(*c*) Determine costs of soil management.

(*a*) *Consider the Objects Sought.* The final object sought in all orchard operations is excellent tree growth and the yearly production of large yields per tree of high-quality fruit at as low a cost as possible. Inasmuch as soil moisture, nitrates, and organic matter are important factors in securing these desirable conditions, and since they are decidedly influenced by the manner in which the soil is handled, it will be well to determine some of the objects sought in orchard soil management.

Some of these objects are: (1) the conservation of moisture, (2) keeping up a good nitrogen supply, (3) the addition of organic matter, and (4) maintaining a proper physical condition of the soil. It is difficult to separate these four factors, since it can readily be seen that, if a good supply of organic matter is added, the physical condition of the soil would be improved, the nitrogen supply probably would be increased, and the water-holding capacity of the soil would be greater. The great importance of organic matter in orchard soils can thus be realized.

Considering these points in relation to orchard culture, it is evident that certain soil practices might be better than others. Likewise, a certain practice might be satisfactory under one set of soil, weather, and topographical conditions and unsatisfactory under a different set of conditions. Although a system of clean cultivation and cover crops is very satisfactory on level land, it might be quite unsatisfactory on steep lands where soil erosion would occur and where the cost of tilling the soil would be very great. Although trees might grow well in rough, rocky land, it would be very expensive to cultivate such land, even if it was possible to do so.

When organic matter, such as a green manure crop, is plowed into the soil, it is decomposed and most of it is changed into nitrates before it is used by the trees or other plants. Various soil micro-organisms such as fungi, algae, and bacteria carry on these changes in the soil.

(*b*) *Consider the Different Soil-Management Systems Which Might Be Used.* Many different systems of soil management have been and are being used in different orchards of this country. Some of these are:

(1) Sod culture—grass not cut.

(2) Sod culture—grass cut and removed, or pastured.

(3) Sod mulch—grass or legume cut and raked under limbs of young trees, not raked up in old orchard.

(4) Sod mulch plus additional mulch.

(5) Clean cultivation and intercrops while the trees are young.

(6) Clean cultivation, strip cultivation, and alternate-row cultivation.

(7) Clean cultivation and cover crops.

It will be seen that the different systems of soil culture fall into two large, general groups: **sod** versus **tillage.** In general, the nitrate content of the soil is found to be much less under a system of sod culture than where a system of clean cultivation and cover crops is used, and orchards in sod usually respond well to applications of a quickly available nitrogen fertilizer. In addition to the fact that the grass itself uses nitrates, it has been found that nitrification is much slower and less extensive under sod than in cultivated soil. Likewise the amount of soil moisture is usually less in the sod orchard, unless a heavy enough sod is produced so that an efficient mulch results when the grass is cut and left upon the ground. Under that procedure the moisture content of the soil appears to be about the same in the sod and cultivated orchard during most of the year, especially in the deeper and richer soils. Additional mulching material, such as straw or hay, added to the cut grass will usually insure a soil moisture content equal to that of the cultivated orchard, even under soil conditions unfavorable for a good growth of grass or permanent legume. The danger of injury to the trees from mice and other rodents and from fire is greater in the sod than in the tilled orchard.

(1) Sod Culture: In this system, fertilization is usually not practiced, the sod is thin and poor, and the grass is not cut.

From the standpoint of the effect on the trees, this system is generally injurious in most orchards. The grass competes with the trees for both water and nitrates. Practically always the soil in such orchards contains less water and nitrates for the trees than the soil in orchards which are cultivated and in which cover crops are plowed under each year. Trees in such orchards usually have a yellowish foliage, the terminal growth and spur growth are weak, the set of blossoms is usually poor, the leaves fall early in the autumn, and the yields are small. Heavy fertilization, especially with nitrogen for the trees and phosphorus for the grass, is beneficial. The system is not recommended unless the soil is unusually fertile, and unless some unusual supply of soil water from springs, seepage, or some other cause is available most of the year. In irrigated sections, its use might be permissible or even advisable in order to increase the organic matter of the soil, especially if alfalfa were used instead of grass. The grass or alfalfa, especially in bearing orchards, should not be removed.

(2) Sod—Hay, Cut, or Pastured: Under most conditions it will not be profitable to cut hay from an orchard. Such a practice robs the trees of both moisture and nitrates and should never be practiced in the bearing orchard. In commercial orchards it will not pay to pasture the land. Horses and cattle and even sheep will remove the foliage, fruit spurs, and apples as high as they can reach. It is possible for a farmer with two or three acres of orchard to use it as a pig pasture, but, if more than three or four pigs per acre are placed in the orchard, they may do considerable damage to the roots of the trees and the sod, unless care is taken to keep rings in their noses. In any case some protection should be provided around the trees, especially while the trees are young.

(3) Sod Mulch: This system differs from sod culture in that an attempt is made to get a heavy growth of grass by means of fertilization. The grass is cut at least twice during the season and piled about the trees, while they are young, to form a heavy mulch over the roots (see Fig. 162 *b, c, f*). This system may prove satisfactory, at least until the roots extend out and occupy so much soil that enough grass would not be produced to form a sufficient mulch. Certain experiments

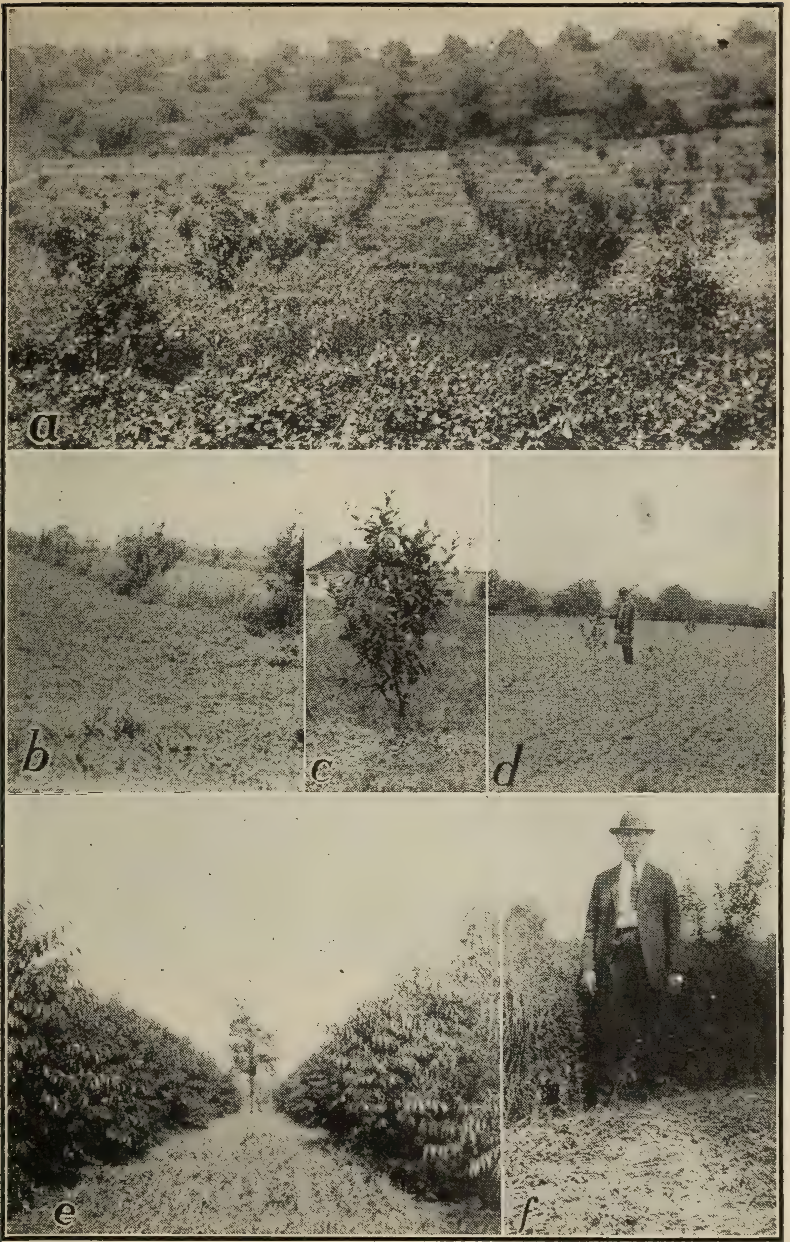
indicate that a legume sod, such as alfalfa or sweet clover, would, under most conditions, be more satisfactory than a mixture of grasses. The sod-mulch system would no doubt be satisfactory in orchards planted on deep, fertile soils, and this system, or some modification of it, would be highly desirable in orchards located on steep or very stony and rocky land, on land which tended to be too damp because of seepage from springs, and where there are other special factors. The application of sufficient nitrogen fertilizers may make the sod-mulch system very satisfactory.

(4) Sod Mulch Plus Additional Mulch: Many orchards are grown satisfactorily under a system of sod mulch plus additional mulch. In this system, in addition to the grass which is cut twice a year and piled about the trees, other mulching material such as straw, hay, or cornstalks is hauled in and piled under the spread of the branches. About 50 pounds of air-dried material per tree should be piled around trees ranging from 1 to 4 years old. This amount should gradually be increased to 100 or 125 pounds around a 10-year-old tree. In older bearing orchards, from 200 to 300 pounds of such material should be spread about each tree. The mulch should not be placed close to the trunk, since injury from mice is greater in such cases, but it should extend well out beyond the spread of the limbs in order to cover the root system of the tree.

This system on good soils produces approximately the same effects as clean cultivation plus cover crops. The loss of soil moisture is apparently prevented just as well, and the heavy mulch kills out the vegetation directly over the roots so that its growth does not injure the trees.

Trees under such a system make excellent growth and are quite productive. The fruit is often of better color than in cultivated orchards, and the apples which drop are protected and kept clean by falling on the mulch.

Under many conditions a nitrate fertilizer should also be added to the trees, and it will probably pay to fertilize the grass



(*Md. Exp. Sta.*)

Fig. 162. Different soil management systems. (a) Clean cultivation followed with cow peas as a cover crop. (b) Permanent sod of alfalfa which has just been cut. The strip in the tree row will be cut next and then the trees will be heavily mulched with the cut material. (c) Sweet clover sod mulch. Note the thick mulch of clover piled around the tree. (d) Clean cultivation in a young apple orchid. A cover crop will be sown in late July. (e) A good cover crop of rye starting in a young peach orchid. It was sown early in the season—August 1. (f) Sweet clover as a permanent sod mulch. Note the large amount of organic matter and mulching material produced by this crop.

in the center of the rows with nitrogen, phosphorus, and possibly potash in order to keep up the mulch supply.

Some disadvantages of the additional mulch system: A sufficient amount of cheap additional mulch may not be available, and if this has to be purchased, the system may be more expensive than clean cultivation and cover crops. There is great danger of fire in orchards where so much mulch is used,

(*U. S. D. A.*)

FIG. 163. Beans make a good intercrop in the young orchard.

and it is necessary to take extra precautions against root and trunk injury from mice and other rodents.

It should be said that this system of orchard management is gaining in favor, especially since low returns in recent years have compelled growers to decrease costs where possible and to improve the color of their fruit. They grow their own mulching material on adjoining areas. Sudan grass is promising for this purpose.

(5) Clean Cultivation and Intercrops While the Trees Are Young: While the orchard is young and non-bearing, the trees will not need all the ground, and so intercrops may sometimes

be grown profitably between the trees (Fig. 163). Such crops should consist of any cultivated crop from which money can be made. Tomatoes, beans, potatoes, cabbage, corn, or in fact almost any of the truck crops will be satisfactory. A grain or hay crop, because of the nitrates and moisture used, is not recommended under most conditions.

The truck crops, of course, are fertilized and cultivated, and as a result, conditions for tree growth are also good. The rows of crops should be kept a few feet from the tree rows, this distance being increased each year until intercropping ceases. A cover crop should be sown each year at the last cultivation of the cultivated crop so that the organic-matter content of the soil may be increased when the cover crop is turned under.

(*Md. Exp. Sta.*)

FIG. 164.—Strip cultivation. Tree rows cultivated, with permanent alfalfa between the rows cut for hay.

(6) Clean Cultivation, Strip Cultivation and Alternate-row Cultivation: The practice of cultivating orchard soils from early spring until late in the fall without seeding or allowing any cover crop to grow means that, sooner or later, tree growth and fruit production will seriously diminish. Such soils gradually become devoid of organic matter and nitrogen, moisture is not absorbed or held, and the soils puddle in winter and bake and crack in the summer. As a result of such soil conditions, tree growth is checked, the foliage looks yellow, and smaller crops of poor-sized fruit result. If such orchards are growing on slopes or hillsides, soil washing occurs and fertility is lost.

In young orchards, growing on steep land, a combination of cultivation and cover crops along the tree rows, with sod mulch in the center of the rows to prevent washing, is often profitable and satisfactory. This system is also occasionally used in young non-bearing trees on level ground (Fig. 164.) It is very questionable, however, whether it pays to cultivate the tree rows in orchards on very steep land. It would, no doubt, be just as satisfactory to use the sod mulch plus heavy fertilization over the entire area.

With older orchards, alternate cultivation is often used, every other row being cultivated one year while the remaining rows are in sod mulch. The following year the systems are reversed and the cultivated rows are seeded down. By these means erosion is prevented and a part of the orchard is cultivated each year. In the past this system has often seemed advisable, but whether it will continue to be so in the future, in view of the satisfactory responses being obtained in sod-mulch orchards when heavier applications of nitrogen fertilizers per tree are used, is questionable.

(7) Clean Cultivation and Cover Crops: Unless the orchard is planted on very steep land, the system of clean cultivation plus cover crops will generally be found to be very satisfactory and profitable. On level land, no other system can quite equal it in many cases, unless a very large supply of some cheap additional mulch is available for use, as outlined previously.

The clean cultivation and cover-crop system consists essentially of plowing the ground early in the spring, harrowing or disking it several times through the summer in order to kill weeds and keep a good dust mulch on the surface, and finally sowing a cover crop, which is to be plowed under later (Fig. 162 *a*, *d*, *e*). In some of the lighter soils, disking can be substituted for plowing, but even then it will generally pay to plow at least once in every three or four years, in order to prevent the formation of a hardpan layer just beneath the depth to which the disk reaches.

By cultivation, weeds are destroyed; the soil becomes better aerated and warmer; the soil particles are broken up into smaller pieces, thus presenting a greater feeding area for the roots; nitrates are produced early in the spring and in large quantities through increased nitrification; the water of rains is quickly absorbed, and the loss of water is prevented through weed control and to some degree by the dust mulch kept on the surface of the soil.

Organic matter is added by plowing under the cover crops, and nitrogen, in addition to that already in the soil, is incorporated when legume cover crops are used. The organic matter of the cover crops improves the physical condition of the soil and increases its water-holding capacity. The decaying organic matter liberates carbon dioxide, which makes a stronger acid soil solution, so that the other mineral foods already in the soil are more readily dissolved and made available for the tree's use. Nitrification normally proceeds much earlier and faster in cultivated soils, and as a result more nitrates are available for tree growth than where sod culture or sod mulch is used.

Plow in the Fall or Early in the Spring. In regions like southern New York and Pennsylvania where there is little danger from winter freezing of roots, and where the cover crops have been sown early enough in the season to produce a large bulk of organic matter, it will probably pay to plow in the fall (except in very sandy soils), especially if the orchards are not on steep land. By fall plowing, earlier cultivation can usually be performed in the spring, the organic matter will decay sooner, nitrification will start earlier, and there will be no danger of the cover crops competing with the trees for water and nitrates early in the spring.

In regions with a climate similar to that of Maryland, Delaware, Virginia, and North Carolina, plowing can be done during the fall or in February and March. The important thing is to have the ground plowed before any tree growth starts in the spring.

The reason for cultivating early in order to increase the amount of water and nitrates available for the tree is readily understood when it is recalled from Chapter IV, "The Growth of the Tree and the Forming of Fruit Buds," that fruit spur growth in length is completed for the season about two weeks after blossoming and that terminal growth (at the ends of the branches) is completed about the middle of July, in most sections. This means also that the full leaf area is developed early in the season, and that large amounts of water are thus being transpired. It will also be recalled, from Chapter VIII, "Pollination and Fruit Setting," that the "set" of blossoms is influenced considerably by the amount of moisture and nitrates available at blossoming time.

It is thus evident how essential it is that nothing shall compete with the trees so that the maximum amount possible of moisture and nitrates will be available early in the season, when such rapid tree growth and development are taking place. If the cover crop is allowed to grow in the spring, much of the water and nitrates is taken from the trees. Early cultivation not only will prevent moisture loss, but also will help to bring about such favorable conditions of temperature and aeration in the soil that nitrification early in the season will be more rapid and extensive.

Trees will respond better if plowing is done early than if the plowing is done late, even though later cultivation may be very thorough.

Determining the Cover Crop to Use. There are, in general, two kinds of cover crops, **legumes** and **non-legumes.** The legumes, through the aid of bacteria which are present in the nodules on their roots, are able to fix the nitrogen of the air, but non-legumes do not have this power. It can thus be seen that, with legumes, more nitrogen than that which was already in the soil before the crop was grown is added when the crop is turned under and nitrification has taken place. On land where legumes have never been grown, inoculation may be necessary. If both legumes and non-legumes are used as cover crops, the soil nitrates which might otherwise leach out of the soil or be washed away are absorbed by the plants and thus returned to the soil when the crop is turned under.

Winter vetch, crimson clover, cow peas, soy beans, alfalfa, and red clover are legumes. Crops such as rye, oats, millet, sorghum, buckwheat, rape, and cowhorn turnips are non-legumes.

The choice of the cover crop will vary under different conditions. In general, that crop should be selected which will make the best growth at the lowest cost in the locality where it is grown. If leguminous crops will thrive and produce large amounts of organic matter, rich in nitrogen, they should be used. But remember that a large amount of organic matter is the important thing in order to improve the physical condition of the soil and especially its moisture-holding capacity. As a result, if the non-legumes will thrive better under certain local conditions and thus produce more organic matter, they should be used, as additional nitrogen can easily and cheaply be added in the form of some quickly available nitrogen carrier.

Fig. 165. A cover crop of buckwheat.

In the old orchard a cover crop which is least affected by shade should be given preference. It is usually advisable also to grow a crop which is not killed by the first frost in the fall. Thus such crops as rye and vetch will continue growth after the leaves of the trees have fallen in the autmn and will make satisfactory crops under such conditions. If late fall plowing is not practiced, then very early spring plowing should be done in order to prevent the cover crop from making too much spring growth and thus competing with the trees for moisture and nitrates.

Much of the organic matter produced by those cover crops which are killed by early frosts may be lost by having the leaves blown away. This is often true with cow peas and soy beans, for instance, where the orchard is located on an ex-

FIG. 166. A weed cover crop may often be spotted and thus not produce sufficient organic matter. In such cases a standard cover crop should be seeded.

posure swept by strong winds. Often only the stalks remain on the ground in the spring. In orchards where fall or winter plowing is practiced, this condition is avoided to some extent.

Often a weed cover crop, such as foxtail, chickweed, ragweed, quack grass, or partridge pea, will grow quickly and cover the ground as soon as cultivation is stopped in the late summer. Such crops will add considerable organic matter and fulfill many of the functions of a standard cover crop. A good stand of volunteer grass or weeds is preferable to a poor stand of certain cover crops and saves money. The use of weeds is questionable, however, since they often come up unevenly (Fig. 166) and are a source of spreading obnoxious weeds about the farm. This last objection would not be as serious on a specialized fruit farm as it would be on a general farm.

Winter Vetch. Winter vetch often makes an ideal leguminous cover crop, and good stands are not difficult to obtain. It will usually grow in a season too dry for clover, and on soils too acid for good stands of clover and alfalfa. It grows in cool weather and makes a heavy mat upon the ground. In combination with rye or oats, it makes an excellent cover crop. Its main disadvantage in some years is the high price of seed.

Crimson Clover and Red Clover. Crimson clover makes an excellent cover crop where good stands can be obtained. Many orchardists, however, have difficulty in getting a good stand. It is rather exacting in its moisture requirements at seeding time and winter-kills badly in some of the Northern fruit sections. It will not do well on acid soils.

Red clover and mammoth clover are also popular cover crops where good stands can be secured. The cost of seed is likely to be high.

Alfalfa and Sweet Clover. Alfalfa is used occasionally as a cover crop by some fruit growers. Where soil and climatic conditions are favorable for a good stand and quick growth, it should be a satisfactory cover crop. In many orchard sections it is very difficult, however, to obtain a desirable stand and growth during the period when the crop must be grown. The soil should be well drained, fertile, and limed if acid. Inoculation is important. Growers usually have much better success in using alfalfa as a permanent orchard sod than as a cover crop.

The biennial white sweet clover, like alfalfa, gives promise of being satisfactory as a permanent sod in orchards. It will thrive on poorer soils than alfalfa. It is quite possible that this clover, and in addition the white annual variety, may be suitable as cover crops in some orchard sections.

Soy Beans and Cow Peas. Soy beans and cow peas make good cover crops in the South, but are not so popular in the North. The fact that they are killed at the first frost is an objection. In the South these crops need to be fertilized on most soils if a sufficient bulk of organic matter is to be produced.

Rye and Other Grains. Rye is a very satisfactory non-legume cover crop. It grows well in cool weather and lives over winter. It should be plowed under in the winter where possible or early in the spring, or it will compete with the trees for both moisture and nitrates. The fact that it grows well even on poor and acid soils where a little fertilizer is used, and produces a large amount of organic matter, makes it a very valuable cover crop in many sections. Oats, barley and wheat are also used as cover crops.

Buckwheat. Buckwheat makes a good cover crop in many orchards. It will do quite well on poor soils and thus improve them so that legumes can be grown. It is particularly good for improving the physical condition of a heavy soil. It is killed by the first frost.

Dwarf Essex Rape and Cowhorn Turnips. These have rather large root systems which penetrate the soil deeply and are thus effective in improving its physical condition. These crops grow rather late in the season and generally form a dense mass of leafy material for plowing under. They thrive exceptionally well on heavier soils in cool climates and where there is a good moisture supply.

Millet. Millet makes an excellent cover crop in young orchards where shading is not a factor. Under such conditions it quickly produces a large bulk of organic matter. It does quite well on a wide range of soils and is not very exacting in its moisture requirements.

Time of Seeding. The time of sowing the cover crop is influenced by such factors as: locality, age of trees, variety of fruit (whether summer or winter apples), type of soil, and size of crop.

If the cover crop is sown too early in an orchard which is producing a heavy crop of fruit, the size of fruit may be injured under some conditions. It must be remembered that the cover crop draws heavily on the moisture supply of the soil. With a heavy crop of fruit the cover crops should generally be sown later than if the trees are not bearing.

Cover crops can be sown earlier on heavy soils that are retentive of moisture than on the lighter soils. Early sowing of cover crops will check tree growth and thus help to bring about a satisfactory maturity of young trees, so they will be in better shape to withstand low winter temperatures.

Under many soil and climatic conditions, and especially in the Middle Atlantic states, the cover crops should be seeded early enough (late July) so that a large bulk of organic material will be produced and available for plowing under in late fall, winter, or early spring. A test for lime should be made, and lime and fertilizers should be added if these are necessary in order to produce a heavy cover crop. Nitrogen, phosphorus, potassium, and lime may all have to be added on some soils to get a good growth of cover crops. Inoculation may be required for the leguminous crops.

The first year that cover crops are sown early they may reduce the soil moisture content to such an extent, especially in a dry season, as to affect the size of the developing fruit. The following year and thereafter, however, the soil moisture content will usually be so much higher because of the organic matter turned under previously that the growth of the cover crops will probably not affect the growth of the fruit adversely, except under unusual drought conditions.

Rate of Seeding. Following are suggested amounts of seed to use per acre in seeding the orchard cover crops.

It is often advisable to use mixtures of the above cover crops, reducing somewhat the quantity of seed of each kind.

Legumes	Amount of Seed to Use per Acre
Crimson clover	15 to 20 pounds
Red clover	12 to 15 pounds
Alsike clover	6 pounds
Winter vetch	½ to 1 bushel
Cow peas	1½ to 2 bushels
Soy beans	1 to 1½ bushels
Non-legumes	
Rye, oats, or barley	1½ to 2 bushels
Buckwheat	1 bushel
Millet	25 to 40 pounds
Rape or cowhorn turnips	2 to 4 pounds

Thus in many orchards, a mixture of 10 to 15 pounds of winter vetch and 1 to 1½ bushels of rye makes a most excellent cover crop.

(*c*) *Determine Costs of Soil Management.* Cost of orchard soil management depends upon the size of the orchard, the type of equipment used, and the kind of soil management practiced. If an orchard is kept under clean cultivation, it must be either disk-harrowed or plowed and kept in proper condition by later harrowings. A sod orchard or one in which each year a system of sod mulch is practiced needs only to be mown once in June and perhaps again in September. The grass which is close to the trees may be cut with a scythe. Soil management undoubtedly costs less in a sod orchard than in a cultivated one. Table 45 indicates costs of all types in New York orchards during 1934, 1935, and 1936.

In the Dale View Orchard in Licking County, Ohio, where an orchard was in sod and mowed twice a year, the grass under the trees being cut with a scythe, the soil-management cost was 3 cents per bushel.

In the Germantown-Red Hook and Kinderhook area of the Hudson Valley in 1931, in 519 orchards where both systems of soil management were practiced, it cost $4.02 per acre or 4 cents per bushel for soil management.

2. Selecting the Implements for Soil Management. For sod orchards about the only implement necessary is a good mowing machine. In young orchards a hay rake is also necessary for raking up the cut material so that it can be piled about the trees.

In cultivated orchards, the size of the orchard determines largely whether a team and ordinary walking plow will be used or whether a tractor and gang plow can be operated profitably. Some of the things which will influence the selection of a tractor are: (1) its cost, (2) topography of the land, (3) the type of soil, and (4) the horsepower developed. On hillside ground, tractors with a caterpillar tread will usually be found most satisfactory. If the soil is a heavy one, and particularly if the grower desires to pull an extra wide (16-foot) orchard disk, the horsepower developed by the tractor is an important consideration.

In addition to the above factors, an orchard tractor should be as low as possible with practically no levers, exhaust pipes, or other mechanical parts projecting up into the air to catch in or injure the branches. The wheels should be covered with fenders to protect the branches, and arrangements for offset hitches should be made. Implements can then be hooked to

TABLE 45]

APPLES—COSTS ON NEW YORK FARMS, 1934, 1935, AND 1936*

Crop year	1934	1935	1936
Number of farms	23	24	21
Bushels marketable apples per acre	131	180	155
Acres of apples per farm	37.3	36.5	38.7
Growing costs per acre:			
Interest, taxes, depreciation on trees, etc.	$15.70	$13.59	$13.90
Nitrogenous fertilizer	2.13	2.42	2.28
Manure	1.77	2.19	2.19
Cover crop	0.05	0.10	0.13
Spray and dust materials	10.55	11.12	11.11
Labor	11.44	11.97	13.22
Horse	2.06	1.60	1.37
Tractor	1.96	2.02	2.15
Sprayer and other equipment	5.72	6.57	5.04
Miscellaneous	3.19	3.56	4.22
Total growing cost	$54.57	$55.14	$55.61
Costs per bushel:			
Growing	$0.42	$0.30	$0.36
Harvesting:			
Labor	0.09	0.10	0.10
Other	0.03	0.02	0.03
Total harvesting	$0.12	$0.12	$0.13
Storing and selling:			
Packages	0.07	0.09	0.08
Commission, storage, transportation	0.05	0.08	0.06
Labor	0.02	0.04	0.05
Equipment	0.01	0.01	0.01
Use of buildings	0.01	0.01	0.01
Other	0.02	0.02	0.02
Total storing and selling	$0.18	$0.25	$0.23
Total cost per bushel	$0.72	$0.67	$0.72
Less: Packages, commission, storage, transportation	0.12	0.17	0.14
Ciders, wood, pasture	0.01	0.02	0.03
Net cost per bushel	$0.59	$0.48	$0.55
Total returns per bushel	$0.87	$0.67	$1.00
Less: Packages, commission, storage, transportation	0.12	0.17	0.14
Net returns per bushel	$0.75	$0.50	$0.86
Profit per bushel	$0.16	$0.02	$0.31
Returns per hour of labor	$0.52	$0.34	$0.79

* Department of Agricultural Economics and Farm Management, New York State College of Agriculture.

the side of the drawbar so that the ground near the trees may be worked without running the tractor near them. It is more

(Caterpillar Tractor Co.)

FIG. 167. A disk at work in an Oregon pear orchard.

important to work the soil close to young trees than older ones, in which the feeding roots are well out between the rows.

The type of plow desirable for orchard use is one of a two-bottom design with ample clearance and penetration. Disk plows are satisfactory on many soil types.

In many orchards, on the lighter types of soils, no plowing is done but a disk harrow is used. Such harrows should be strongly built, heavy, and durable. Orchard disks 14 to 16 feet in width are especially desirable, since the sides of the

(Caterpillar Tractor Co.)

Fig. 168. Clean cultivation in an Ohio orchard.

harrow will extend under the branches and the soil will be cultivated, although the tractor need not be driven close enough to do any damage to the trees (Figs. 167 and 168). For this reason it is usually better not to have the tandem hook up, or one disk ahead of the other, for orchard work, but rather a wider implement in one plane of action.

In some orchard sections nothing but plows and disks are used, but in most sections the spring-tooth harrow is a part of the orchard equipment. These harrows, as well as the light-draft orchard cultivators (Fig. 169), will pulverize and level the soil well.

In some of the heavier and stonier orchard lands, special orchard cultivators with heavy, rigid frames and teeth are of great value in leveling the ground after plowing and in cultivating it during the season.

In addition to the foregoing implements, such tools as the

Fig. 169. This light-draft harrow is a very effective implement on land free from large stones or rock ledges.

spike-tooth harrow, the acme harrow, and the plank drag are sometimes seen in orchards. The last two of these are of value in crushing lumps and in pulverizing the soil in preparation for seeding the cover crops if the soil is not stony; the spike tooth is of value in covering the seed after it is sown.

3. Determining Culture of Other Tree Fruits. The *peach, plum, apricot,* and *cherry* make excellent growth, produce good yields, and thrive well under a system of clean cultivation and cover crops. When proper pruning, thinning of the fruit (with the exception of the cherry), and fertilization, especially with nitrogen fertilizers, are practiced, in addition to thorough cultivation and the turning under of heavy cover crops, little is left to be desired.

Peaches and apricots are very shallow-rooted under most soil conditions, and as a result would probably suffer from lack of moisture when in competition with grass much more than apples would. Although plums and cherries might thrive better than peaches and apricots under a system of sod mulch, still it is very questionable whether results equal to those secured under tillage would ever be obtained.

Like all other fruits, the *pear* thrives well under a system of clean cultivation and cover crops. Because of the fact that growth may be vigorous and succulent under cultivated conditions, thus resulting in more injury from fire blight, pear orchards are often left in sod in order to check such growth. If proper and thorough methods of blight control are practiced, however, it is questionable whether it will pay to check growth too severely, decrease the bearing area, and reduce total yields by keeping the orchards in sod. A system of sod and cultivation in alternate years may be desirable. Cease cultivation earlier in the season than with the apple.

The *quince* thrives best when the soil is cultivated, but appears to do fairly well under sod mulch conditions also. In some regions the quince is so susceptible to fire blight that it is almost necessary to practice some system of sod culture in order to check rapid growth and thus reduce fire-blight injury.

Fertilizing the Trees

The Apple

It is practically impossible to consider orchard fertilization without knowing the system of orchard soil management that is being used and the kind of soil upon which the orchard is growing. If the orchard is located on a heavy loam soil, and is cultivated yearly with cover crops plowed under, it will usually require a different treatment than if it is growing under sod conditions. Cultivated orchards on light, shallow, thin soils often require different and larger amounts of fertilizer than those on heavy, deep soil.

1. Deciding Whether Fertilizers Are Needed. The decision whether the orchard needs fertilizer should follow a careful study of conditions. The color and amount of foliage should be noted; whether the leaves are large, plentiful and dark green, or whether they are small, sparse, and yellowish. The yearly amount of new terminal growth is likewise an index of whether fertilizers are needed. Though the most desirable length of new terminal growth varies with the age of the tree, variety, and seasonal conditions, 14 to 16 inches is usually desirable for bearing trees. The length of terminal growth on young non-bearing trees should range from 18 to 36 inches, depending on the age of the trees. Trees from 2 to 5 years of age should be making the longer growths.

The length and diameter of the new growth produced each year on fruit spurs should also be determined. Non-bearing spurs, making new yearly growths of ½ to ¾ inch, especially if the growths are thick in diameter and are well supplied with numerous, healthy leaves, can generally be counted upon to blossom and set fruit, unless the tree as a whole is in a decidedly biennial bearing condition. Spurs making quite short (1/16 inch) or slender growths usually form very few fruit buds. Likewise spurs which have been forced out into long, slender growths often become unproductive.

The stockiness of the trunk and the general height and width of the trees should be taken into consideration.

2. Deciding Which Fertilizers Are Needed. As stated in Chapter IV, "Growth of the Tree and the Forming of Fruit Buds," apple trees need and use for the proper development of tree and fruit all the essential elements, but experiments have shown that many soils in this country are supplied at present with sufficient available amounts of these minerals so that satisfactory tree growth and fruitfulness are produced without adding them as fertilizers. Sufficient nitrogen for best growth and fruiting, however, seems to be lacking in many soils and on them much better growth and production results whenever it is added (Fig. 170). It is often necessary to add phosphorus, potassium, and lime for the growing of farm crops on the same soils where fruit trees will show no apparent improve-

Fig. 170. The row on the left received an application of quickly available nitrogen fertilizer. The row on the right received none, but was treated the same otherwise. Note the differences in foliage, growth, and yield.

ment in growth and fruiting from the addition of these fertilizers. A possible explanation of this may be that the roots of fruit trees range wider, extend deeper, and penetrate all parts of the soil more thoroughly.

Sod orchards respond well to applications of a readily available nitrogen fertilizer. Cultivated orchards also, except on the heavier and more fertile soils, respond well in many regions.

Though dried blood, tankage, and fish (all organic nitrogen carriers) are beneficial, still most orchards seem to respond better to the more quickly available inorganic nitrogen fertilizers such as nitrate of soda or ammonium sulfate. New nitrogen fertilizers now available may give as good results, for less money, as can be obtained from nitrate of soda. The grower should review the fertilizer situation each year and shop around to determine the best buy.

The addition of phosphorus has been beneficial only in an indirect way, in that it has seemed to improve the nature and amount of the sod in many sod orchards, and likewise has helped in causing a heavier cover crop to be produced in tilled orchards where it was applied at the seeding of the crop.

The popular notion of a few years ago that potash would improve the color of fruit has not been borne out in recent experiments. On the contrary, the development of color seems to depend more on having the fruit well exposed to sunlight and other favorable climatic conditions such as the proper amount of moisture and cool nights, and in having it properly matured. The lack of some of these conditions explains, in part, why fruit from orchards fertilized with nitrogen sometimes has the reputation of being somewhat poor in color. Such fruit is usually produced under more shaded conditions, unless very thorough detailed pruning is given, since the trees make a more vigorous growth, and thus have more and larger leaves. Its maturity is also delayed, and the fruit on vigorous trees should be allowed to hang on the trees longer in order to improve in color as much as possible and reach a stage of maturity equal to that borne on less vigorous trees.

3. Deciding How Much Fertilizer to Use and When to Apply It. The amount of fertilizer to use will depend on the color of the foliage and on the amount of new growth being produced. Each orchard thus presents a different problem. One orchard may, under certain conditions, need a heavy application of nitrogen to bring about desirable growth conditions, whereas another orchard under different conditions may need very little or none.

In orchard sections where it has been found desirable to fertilize most of the orchards each year, the following approximate amounts of nitrate of soda, or its equivalent in other nitrogen carriers, are being used: ¼ pound on 1- and 2-year-old trees, and ½ to 1 pound on 3-year-old trees. These amounts are then gradually increased until 2 to 4 pounds are used for 6- to 10-year-old trees, and 5 to 10 pounds for trees ranging from 15 to 30 years old. These amounts should serve only as a general guide, however, as the growth and fruiting of the tree should be used as an index of how much fertilizer to add.

In general, it is not a good practice to place fertilizer in the hole at planting time; in fact, severe injury to the tree may result. Good results are often obtained by applying the fertilizer on top of the soil in a circle 6 to 8 inches from the trunks after growth of the trees has started.

Since quickly available nitrogen fertilizers are applied to increase fruit spur and terminal growth and the "set" of blossoms, as well as to increase the color and size of foliage and fruit-bud formation, and to influence other factors, it should be remembered that fruit-spur growth in length is generally completed within two weeks after blossoming, and that terminal growth is usually over in most sections and seasons by July 15. These facts being known, it is at once apparent how important it is to apply fertilizers early in the spring (about one month before blossoming).

In orchards on light, sandy soils where considerable leaching may occur, it may pay to split the applications: about two-thirds of the amount decided upon should be applied before the terminal buds start to grow, and the other third just after blossoming when the set has been determined.

Results in some fruit regions indicate that it might be desirable to apply part of the nitrogen in the spring and part in the fall each year, but further studies are needed before growers in all regions should adopt such a practice, except in an experimental way.

Thus far it has not been possible to eliminate biennial bearing through the use of fertilizers.

4. Applying the Fertilizer. When a quickly available nitrogen fertilizer is used in the spring, it is generally applied by hand. Before the fertilizer is taken to the orchard it is removed from the sacks, ground or pounded and screened if necessary, and loaded into a tight wagon box. The wagon is hauled along between two tree rows, and from two to four men apply the fertilizer.

In general, spread the fertilizer about each tree in an area extending from about 3 feet inside of the branches to about 3 feet beyond the spread. Use a cup or small pail previously weighed and marked with the proper amount of fertilizer to apply per tree, to measure the material, refilling the buckets with fertilizer at the wagon as often as necessary. Walk in a circle about each tree when applying the fertilizer. In old orchards (especially sod-mulch orchards), it will usually be best to sow the fertilizer either by hand or with a fertilizer distributor evenly over all the area between the trees.

5. Determining Cost of Applying Fertilizers. The time and cost of applying fertilizer to apple trees varies with such factors as the amount of material applied per tree, the contour of the land (whether steep or not), and the speed of the men.

In the Hudson Valley of New York, where the average rate of fertilizer applied is 5 pounds per tree, the cost of fertilizer and applications average $4.07 per acre, of which $3.28 is for fertilizer, 47 cents for labor, and 32 cents for other costs. (See Tables 45 and 46.)

The average cost per acre for fertilizer and manures applied on 80 orchards in Berrien County, Michigan, in 1935 was $3.84.

For the Shenandoah-Cumberland region the average cost per acre over the 3-year period 1929 to 1931 was $4.18.

Other Trees

6. Fertilizing the Peach, Apricot, Cherry and Plum. Practically all fertilizer experiments in this country have shown that **peach** trees are benefited by applications of nitrate of

TABLE 46

COST OF FERTILIZING 206 APPLE ORCHARDS OF 2124 ACRES, HUDSON VALLEY, 1931

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	Average per Acre Fertilized	Percentage of Total
Time and materials:		
Fertilizer	155 pounds	....
Labor	1.4 hours	....
Horse work	0.7 hours	....
Cost per acre:	*Dollars*	*Percent*
Fertilizer	3.28	80
Labor	0.47	12
Horse work	0.15	4
Interest on costs	0.12	3
Tractor and truck	0.05	1
Total	4.07	100

soda. Larger trees and greater yields have resulted. In the same experiments, except in one or two cases, practically no direct benefit has been derived from applications of acid phosphate, lime, or potash. Some indirect benefit has sometimes resulted by increasing the growth of the cover crop. It is possible, however, that in some of the Southern peach-growing regions, as Georgia and the sand hill sections of North and South Carolina, benefits may be derived from a complete fertilizer.

Sufficient nitrate should be added to cause terminal growths of 16 to 24 inches in length. If too much is added, ripening may be delayed, which might be either advantageous or disadvantageous, depending upon the market conditions, and so much foliage might be produced that the color of the fruit would be poor.

Early nitrate applications have given excellent results, but as peach trees bloom earlier and normally grow later in the season than apple trees, and as early fruit-spur growth is not a factor, it may be wise to delay the application of fertilizer until after danger of frost is over and the "set" of fruit can be determined. If the crop should be lost by frosts, less nitrate, of course, should be applied. It is possible that other nitrogen carriers will be found to be as satisfactory as nitrate of soda for peaches.

Very little evidence is available relative to the fertilization of **apricots,** but since they are so similar in growth and fruiting to the peach and Japanese plum, it is reasonable to suppose that they will respond to similar fertilizer practices.

Sour cherry fertilizer experiments have shown that this fruit also responds well in growth and production to applications of quickly available nitrogen. As a rule, no direct benefit has been derived from the addition of acid phosphate or potash, except in the very light, sandy soils. Practically no fertilizer experiments have been conducted with **sweet cherries,** but it would appear that nitrogen applications would be beneficial whenever these trees show the need of fertilization.

Very little experimental evidence is available relative to the fertilization of **plums,** but orchard observations indicate that nitrogen applications will generally be beneficial for all commercial species, if satisfactory growth and yields are not being secured without them.

The Pear and Quince. Since both these fruits are so susceptible to fire blight, it is very questionable whether any fertilizer should be added to the cultivated orchard, unless the soil is so low in fertility that very little growth results. If the orchards are in sod, it will probably pay to add small amounts of a quickly available nitrogen carrier, such as nitrate of soda, about a month before growth starts. This will stimulate early growth and assist in the setting of fruit. The growth of grass will tend to check later tree growth and encourage hardening of the wood, making the trees more resistant to fire blight.

DIAGNOSING GROWTH CONDITIONS AND PRESCRIBING TREATMENT

The various practices to be adopted for each orchard should be determined only after a careful study of tree growth, yields, and environmental conditions. In diagnosing individual orchards the following factors should be considered: (*a*) Color of foliage—is it dark green or yellow and sickly looking? (*b*) Height of tree—is it dwarfed for its age or overgrown? (*c*) Height and width of tree—is it very tall and narrow, or is it a well-balanced tree? (*d*) Total growth—is it making a satisfactory growth of new wood each year? (*e*) Length of terminal growth—is the terminal growth 3 inches or 4 feet in length? (*f*) Is the tree productive—are the fruit spurs numerous and vigorous, and are fruit buds formed?

With this information the physiological condition of the tree can be diagnosed and intelligent treatments prescribed.

By referring to Chapter IV, "The Growth of Tree and the Forming of Fruit Buds," the four classes in which plants can be grouped according to the proportion of carbohydrates and nitrogen within their tissues are evident. With the aid of this classification, proper treatments can be prescribed. For instance, it is readily apparent that a seven-year-old orchard, on fertile, moist soil, which is being pruned heavily, cultivated thoroughly, and nitrated heavily so that a vigorous growth of wood is produced, but no fruit buds, is in Class II. In this orchard, less nitrogen should be applied and lighter pruning of the tree should be practiced in order to have proportionately more carbohydrates and less nitrogen in the tissues of the tree. When this is accomplished, the trees would be in Class III, producing only a fair growth and good crops.

Let us assume another example. If a middle-aged orchard is growing under sod conditions on poor soil with no fertilization, growth of fruit spurs and terminals would probably be very short, and few fruit buds would be formed. Since very little growth is taking place, carbohydrates would probably accumulate in the tissues. Such trees would be in Class IV, and it is readily apparent that heavier applications of nitrogen, cultivation of the soil, and a heavier pruning would be beneficial. Such a treatment would cause such trees to approach Class III, resulting in better growth and fruiting conditions.

In some sections, especially in parts of New York and New England, difficulty has been encountered with the development of what has been termed "internal cork" in the flesh of the apple—large brown areas not noticeable on the surface. Many of the affected fruits drop prematurely. The condition is accentuated by drought conditions during the growing season.

The difficulty seems to lie in a deficiency of boron in the soil. When the supply falls below a certain level, the symptoms described appear.

Treatment of the soil with borax has given almost complete control. Apply it at about the season of the delayed-dormant spray application in a circle about 2 feet wide under the outer tips of the branches. Measure amounts carefully and distribute them evenly. A treatment once in three years seems adequate. Do not treat normal trees showing no evidence of the disease. Amounts for trees of varying sizes are given in Table 47.

COMMUNITY STUDIES

1. Make a survey of the orchards in your community and determine the different methods of soil management being used.

2. Which method of soil management results in best tree growth and yield?

3. Determine the time of the year when the cover crops are seeded. Which cover crop seems most satisfactory under your conditions? Why?

4. How much organic matter (green weight per acre) is produced by the different cover crops?

5. How much does the seed of the different cover crops cost per acre?

TABLE 47

RATES FOR APPLYING BORAX TO TREES OF DIFFERENT SIZES

Approximate Trunk Diameter 1 Foot above Ground	Amount of Borax for for Ring Application on Soil
Inches	*Ounces*
3½	2
5	4
7	6
10	8
14	8–12
15 up	12–16

6. Does the addition of fertilizer increase the amount of cover crop produced?

7. Which orchard cultivation implements are being used in your community?

8. How many orchardists disk instead of plow their orchards in the spring?

9. Determine the kinds and amounts of different fertilizers being used in your community. Which fertilizer appears to give the best results?

10. Do sod orchards appear to show a greater response to fertilization than cultivated orchards?

11. If part of an orchard is in sod and part in cultivation, determine which part is making the better growth. Do they respond equally to the same amounts of fertilizer?

12. If possible get some orchardist to allow you to apply different kinds and amounts of fertilizers to different rows in his orchard. Note the color and amount of foliage produced, the length of spurs and terminals, and the yield of fruit.

13. Which orchardist has the best-colored and largest-sized fruit in the community? How does he prune, spray, manage the soil, thin the fruit, and fertilize his orchard?

14. Visit several orchards in your community and diagnose their conditions. Study:

a. Amount, size, and color of foliage.
b. Length of terminal growth.

c. Number of new spurs being formed each year.
d. Length and thickness of fruit spur growth.
e. Height and width of tree.
f. Total length of growth being produced.
g. Number of trees per acre.
h. Productiveness of trees.

15. In which group or class would you place these trees? Refer to Chapter IV.

16. Note the type and amount of pruning, kind of soil management, and kind and amount of fertilizers being used.

17. Determine whether you would change any of the practices being followed. Support all suggested changes with reasons.

CHAPTER X

THINNING FRUIT

Fruit trees often set more fruit than they are able to bring to maturity in marketable condition. This is true even after the grower has given proper attention to pruning, spraying, soil management, and other standard orchard practices.

Thinning the fruit on the trees under such conditions is an operation that has justified itself in many careful tests. It is now a part of the plan of orchard management of many successful growers. Thus far it has been confined primarily to the apple, peach, and plum.

Operations:

1. Consider conditions under which thinning is advisable.
2. Consider results that may be expected from thinning.
3. Determining time to thin.
4. Thinning apples.
5. Thinning peaches.
6. Thinning plums.

1. Consider Conditions under Which Thinning Is Advisable. Thinning accomplishes very little unless the tree is carrying at least a moderate crop. It will accomplish relatively more as the load on the tree approaches a heavy or full crop. Thinning may be worth while if one side of the tree is heavily loaded and the other side has no crop, because the size of the fruit is largely determined by the leaf surface adjacent to the individual specimen and available for its development. Only judgment and experience will indicate the point at which the operation becomes sound practice.

Varieties naturally medium or small in size will need thinning when varieties naturally above medium or large in size may not require it. The Winesap, Wagner, and Wealthy may require thinning when Arkansas (Mammoth Black Twig) and Tompkins King may not.

Fig. 171. When good pollination occurs, the fruit may set so thickly that it must be thinned to obtain good size and color.

Thinning is relatively more necessary on mature trees making small annual growth or on trees reduced in vigor with thin leaf surface than on young, vigorous trees of the same varieties; on trees grown on light soils deficient in moisture than on trees grown on heavier loams with an abundance of moisture; on trees growing in sod than on trees grown under a mulching system or under a program of tillage and cover crops.

Thinning is more necessary in growing fruit to be packed in boxes or Georgia carriers, or for fancy trade where it is essential that it be uniform in size and color, than if it is to be packed in containers for a less discriminating trade. It is becoming increasingly apparent, however, that fruit sold in any closed package for any market must be of a higher standard of excellence and uniformity than has been acceptable in the past.

2. Consider Results That May Be Expected from Thinning. Thinning under proper conditions gives the following results:

(*a*) Increases proportion of high-grade fruit.
(*b*) Reduces breakage of top.
(*c*) Reduces handling costs at harvest.
(*d*) Does not decrease total yield.
(*e*) Does not insure annual bearing.

(*a*) *Increases Proportion of High-Grade Fruit.* Thinning insures a much larger proportion of fruit in the higher grades by increasing the size of the remaining specimens and by removing defective fruits at the time of the operation. This is its greatest service to the grower and one which has been established and confirmed many times by careful experimental work.

The fruit on a twelve-year-old Stayman Winesap apple orchard of medium vigor was thinned in 1926 by the Maryland Experiment Station. The results are indicated in Table 48.

TABLE 48

INFLUENCE OF THINNING ON SIZE OF STAYMAN WINESAP APPLES

Distance Thinned in Inches......	(Diameter of Fruit in Inches)								Total Yield
	0–2¼		2¼–2½		2½–2⅞		2⅞ Plus		
	bu.	*percent*	*bu.*	*percent*	*bu.*	*percent*	*bu*	*percent*	*bushels*
6-8 inches.......	.75	5.3	2.25	15.0	10.5	71.2	1.25	8.47	14.75
9-10 inches......	0	0	.12	.96	2.38	19.4	8.75	79.6	12.25
Unthinned check.	2.25	15.28	6.0	40.68	6.38	43.21	.12	.81	14.75

It can be seen that all the thinned trees produced fruit of much better size than the checks. The total yields on trees thinned 9 to 10 inches apart were somewhat reduced. The greatest quantity of marketable fruit was produced from those trees thinned 6 to 8 inches apart. As much marketable fruit was produced on the trees thinned 9 to 10 inches as on the checks, and the fact that the fruit from these trees was much larger than that from either of the other groups resulted in a greater net return from these trees. On the trees thinned 9 to 10 inches apart, approximately 80 per cent of the fruit was over 2⅞ inches in diameter compared to 8.5 per cent in the 6- to 8-inch group and less than 1 per cent in the checks.

(*N. J. Exp. Sta.*)

FIG. 172. When fruit is borne in clusters, the specimens are variable in size and are especially subject to insect and disease attacks.

The thinned fruit was also noticeably better in color, more uniform in shape, and freer from all blemishes. Similar results were secured from eighteen-year-old Stayman trees on good soil. They are typical of results obtained elsewhere.

Michigan studies have indicated that from one-third to one-half of the apples put in B grade rather than A grade are so placed because of lack of size.

Results equally striking have been secured repeatedly in increasing the size of peaches and plums and in increasing the proportion of high-grade fruit.

Thinning also has a favorable influence on color, which is of great importance from the standpoint of grade. In the first place, many of the specimens so placed on the tree as to color poorly are removed in the thinning operation. The crop that remains is thus more uniform in color. By removing part of the crop more sun reaches the remaining apples and these color better. Beyond this point, however, thinning seems to accentuate development of color. This is particularly true of peaches. The net result is a crop running better in size and color, of greater uniformity, and of more merchantable quality.

(*b*) *Reduces Breakage of Top.* Thinning reduces breakage of the top, sometimes very serious, and the necessity for propping with its attendant cost. The weight of the crop as it approaches maturity is very great, the leverage on the branches tremendous, and the danger of consequent injury, especially in the presence of high or sudden winds, is much aggravated. Thinning insures an even distribution of a crop that the tree is better able to carry.

(*c*) *Reduces Handling Costs at Harvest.* Thinning saves handling costs at harvest time by reason of the elimination of the undersized and defective specimens. Growers know that such fruits increase greatly the costs of grading and packing, without bringing a corresponding return. A crop 75 per cent of which will go in the upper grade with almost no culls is much less expensive to handle than one that runs less than 50 per cent in the upper grade with a large proportion of culls. The cost of thinning is therefore largely offset by the reduction in handling costs at harvest time. It is cheaper to pick at thinning time than at harvest because labor costs less and because the specimens are dropped as soon as separated from the stem or spur.

(*d*) *Does Not Decrease Total Yield.* Unless carried to extremes, thinning does not decrease the total yield of fruit. Many growers claim that it results in an increased yield. Careful tests have indicated, however, that there is little influence on total yield, under ordinary conditions. Thinning increases both the total yield of marketable fruit and the proportion of such fruit that packs in the upper grades. These are the factors of concern to the grower.

(*e*) *Does Not Insure Annual Bearing.* It is often claimed that thinning promotes or insures annual bearing, and that a biennial bearer may be made to produce a crop each year by judicious thinning. Evidence to date disproves the assertion, at least for the apple. Note the statement on this factor under "Thinning Peaches." It has been noted, however, that trees that have borne a moderate crop seem to possess greater resistance to severe winter temperatures than trees that have carried an excessive crop.

3. Determining Time to Thin. Growers are familiar with a natural dropping of fruit usually occurring in June and commonly termed the "June drop." This is probably due in part to lack of sufficient water and food for all the specimens and in part to diseases on the stem and to insect injuries. There is little doubt that lack of sufficient water and nitrates for all the fruit influences the dropping of individuals on weak spurs and those with few seeds (faulty pollination).

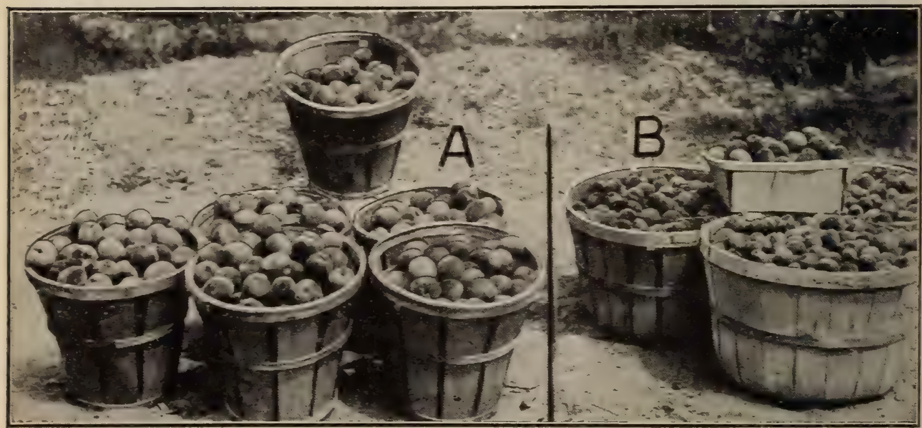
Thinning should preferably follow the June drop while the fruits are small, but it has been found that the period during which thinning may be done to advantage is more extended than previously supposed. Early thinning, however, will allow the moisture, mineral nutrients, and elaborated foods to be used by the fruits which are to remain on the tree rather than by those which are to be removed. The most common mistake in thinning is to fail to remove enough fruit. Growers have found that additional thinning later in the season has given good results, though not so marked results as that done soon after the June drop.

4. Thinning Apples. Remove the specimens inferior in size, those malformed and defective, and those so located on the under sides of the lower branches as not to color well. Take off in addition enough good specimens so that those that remain are at least 6 to 8 inches apart, except that a few apples close together on a limb with large leaf area will size up well. The amount of leaf area per apple should be considered. Some varieties tend to set fruit in clusters. Not more than one fruit should be left on a spur. This will usually be the center one if it is a good specimen, since it is in a more favorable position for growth than the others. Apples should not be allowed to touch, since they afford at the point of contact an easy means for entrance of the side-worm broods of codling moth. A few varieties, however, bear in terminal clusters, like Winter Banana and Cortland. These cannot be thinned so that no apples are in contact without reducing the crop considerably.

Fig. 173. These Stayman Winesap apples were thinned to 6 to 7 inches apart. There will be little loss in grading.

Thinning is usually done by hand. Some growers use shears with slender blades, such as grape picking shears. Care must be exercised not to break off the spurs. In thinning by hand, the apple stem is grasped by the thumb and forefinger and the fruit is pushed off the stem with the other fingers. The strain is put on the stem rather than on the spur. Women often are more satisfactory for thinning than men, since they do the work just as well on the average and more rapidly

Cost of Thinning. Thinning costs are influenced by spread and height of trees, cost and quality of labor, the extent of crop on the trees, and other factors. The West Virginia Station found that, with labor at 20 cents per hour and doing the work very carefully, it took 65.3 minutes per tree to thin Ben Davis trees 21 years old bearing 12 to 15 bushels each, or an average of 21.8 cents per tree. It was found that middle-aged



(*Md. Exp. Sta.*)

Fig. 174. Effect of thinning old Greensboro peach trees in a dry season. (*A*) Yield per tree with fruit thinned 6 to 8 inches apart—2½ bushels of peaches, 2¼ inches in diameter, and ½ bushel of peaches 1⅘ inches in diameter. (*B*) No thinning, 1 peck of 1⅘ inch peaches and 3 bushels of culls (less than 1¼ inches).

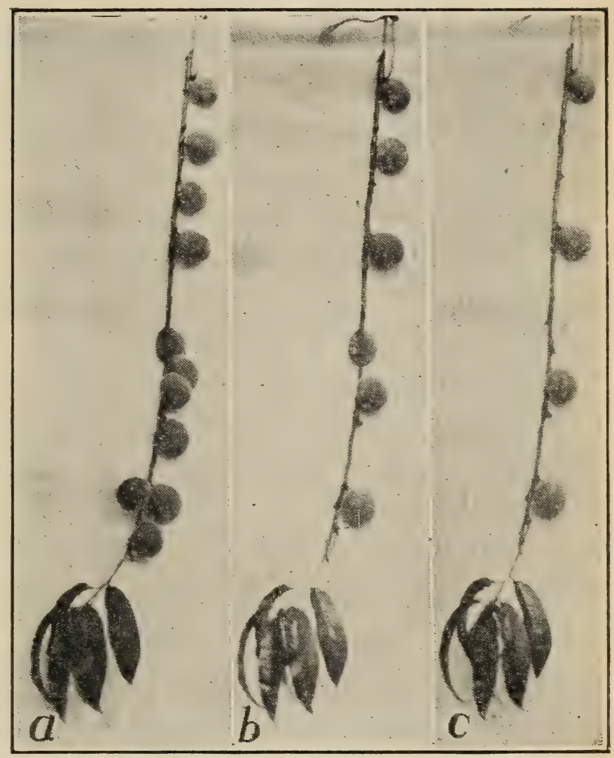
trees with low heads, bearing about 15 bushels per tree, could be thinned on the average for 30 cents per tree. In sections where the cost of labor exceeds 20 cents per hour, the expense would be correspondingly increased.

In large orchards in the Shenandoah-Cumberland district, in 1927, it took on the average 25 minutes per tree to thin 12-year-old Oldenburg (Duchess) trees bearing 4½ bushels of fruit; and 28.2 minutes to thin 15-year-old Wealthy trees bearing 6 bushels of fruit.

Actual or Net Thinning Costs. It has been found in experimental work as well as by commercial growers that the actual cost of thinning is almost negligible. The apples must be picked at some time. Thinning saves handling culls at harvest and grading out undersized fruit. The final crop, as already indicated, is often as large as from unthinned trees; it is of better and more uniform size and color and therefore a much more merchantable product.

5. Thinning Peaches. Thinning the fruit on well-loaded peach trees is a standard orchard practice.

Early varieties, as Carman and Greensboro, respond well to thinning 6 to 8 inches apart, removing 50 per cent or more of the fruit. Later varieties, naturally of larger size, may be thinned to about 4 inches apart, removing from 30 to 40 per cent of the crop. Thinning is especially important in dry seasons and on old trees. Even in young trees on strong soils, the fruit should be thinned so that it does not touch, in order to retard development of brown rot.



(*Md. Exp. Sta.*)

FIG. 175. (*a*) An unthinned peach branch. All the fruit will be small. (*b*) Thinned 4 inches apart. (*c*) Thinned 6 inches apart.

The New York Agricultural Experiment Station at Geneva found, in experiments covering a 3-year period, that the stage of development of the young fruits is a much more reliable index of the proper time to thin than the calendar, and that the time when the fruits are about $\frac{3}{4}$ inch long with the pits still soft is the most favorable from the standpoint of influencing size and color, favorable effects from the operation decreasing gradually beyond that point. It was found also that thinning at the stage indicated did give over the 3-year period larger yields than thinning later in the season. The increase was particularly marked in a light-crop year for peaches in general so that the returns from the trees thinned as indicated were substantially greater.

In the Shenandoah-Cumberland region records from various commercial orchards indicate that it took 32 to 34 minutes per tree to thin large Hiley trees 16 years old, from which 3 bushels of fruit were picked at harvest.

6. Thinning Plums. No fruit responds to thinning more than the plum. This is especially true of the Japanese varieties such as Abundance or Burbank, which often bear fruit almost in ropes along the branches. Under normal conditions thinning from 2 to 3 inches apart leads to a marked increase in size of the specimens without affecting the total yield.

COMMUNITY STUDIES

1. Visit ten of the leading apple and peach growers in the community.
2. Determine how many have thinned and discontinued the practice, and the reasons therefor; how many have adopted it as standard orchard practice.
3. Determine from growers:
    - *a*. Conditions justifying operation.
    - *b*. Time of operation.
    - *c*. Method of thinning.
    - *d*. Results in terms of total crop, proportion in higher grades, cost of harvesting and packing, prices received.
    - *e*. Thinning costs.
    - *f*. Taking into account saving in costs at harvest time by reason of thinning, how much thinning adds to the cost of growing the crop.

4. Compare net income from orchards of growers practicing thinning with income from orchards of those who do not, selecting as nearly as possible orchards having conditions that are similar and comparable in other regards.

CHAPTER XI

FRUIT EXHIBITS AND JUDGING

The educational values in fruit exhibits, both to the grower and the general public, are very great. Such exhibits afford an opportunity to study varieties and to compare their merits for various sections. They offer a stimulus to growers to improve quality as a result of the rivalry between them, and, in case of commercial exhibits, to improve methods of packing. Progressive growers may be noted at any good exhibit taking keen interest in the fruit on display.

The publicity or advertising values in creditable exhibitions are very great. Fruit that is well grown and displayed with good taste and judgment carries an appeal to which the public is very susceptible.

Operations:

1. Selecting fruit for exhibit.
2. Setting up the exhibit.
3. Judging fruit.

1. Selecting Fruit for Exhibit. The first essential is to grow good fruit. The matter thus reverts at once to those factors that constitute good orchard management. Pruning, spraying, and proper soil management all play an important part. Thinning may be of especial importance in promoting size and color.

When the time comes to pick the fruit, handle it with extreme care. Pick several times the quantity that will be exhibited in order to give a wide choice and to allow for losses in handling. The experienced exhibitor will often pick several bushels of his best fruit in order to select from it a few plates.

Stems should not be broken off or pulled out. Fruit in the top of the tree, if it has been well sprayed, is likely to be desirable. It is more exposed to sunlight than that on lower branches and as a result usually has both a higher and more even color.

Early varieties in season before the time of the exhibit may be picked when they have reached their greatest perfection in appearance, but while still firm, and held in cold storage.

If the fruit must be shipped to the exhibit, pack it with the utmost care. For single plates, each specimen should be wrapped and protected from bruising. In fact, this procedure should be followed whatever the manner of taking the fruit to the place of exhibition.

The actual selection of the specimens to be put on exhibition will be governed by the score cards in use and is considered under "Judging Fruit."

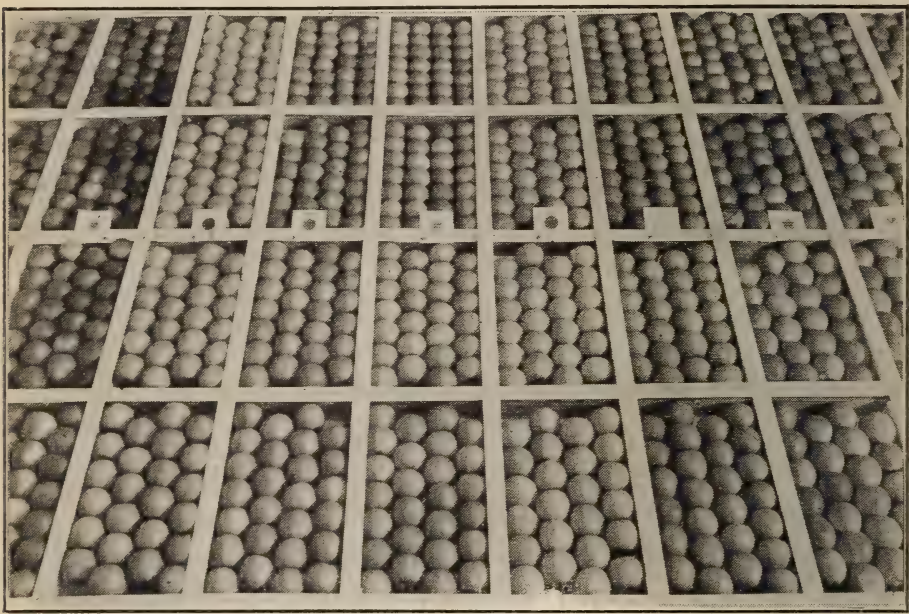
2. Setting Up the Exhibit. In making plans to set up the fruit, all decorations and embellishments should be kept subordinate to the fruit itself. The fruit is the major attraction.

The Background. A neutral background that does not compete for attention with the fruit is best. Subdued tints and tones on walls and tables are in order.

For exhibits of red fruit, dark green oatmeal paper provides a good background on the tables. Greens of various shades are in common use for exhibits. Often the tints are too light and too striking. For light-colored fruit, including pale or green apples, burlap in a natural color is superior to the green oatmeal paper. In fact, it is a very satisfactory shade for use in connection with all fruit. Burlap in a darker tan shade is also good. Wide tables are desirable if they are not so wide as to prevent study of the fruit in the centers.

Arrange Fruit for Mass Effect. This may be secured by putting the fruit on the interior tables all on the same level. Fruit in packages may be banked about the sides of the room to good advantage. The effect of many exhibits at fairs and other places of display is greatly lessened by arranging the fruit on shelves or in tiers so that the eye must be raised from one level to another, encountering drapes of bunting or paper in pronounced patterns between.

Plates. Paper plates are less expensive than china and on the whole look better, since they lack the gloss of glazed plates. A papyrus plate with rough finish is more attractive than a smooth paper plate. A rolled edge adds to the strength of the plate and lessens danger of breaking it when it is picked up. A



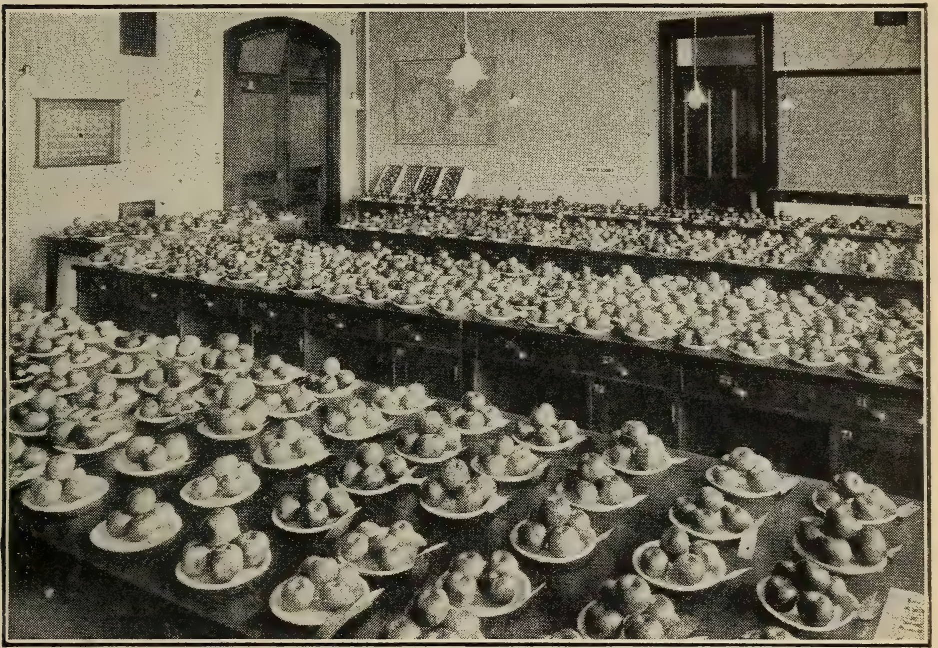
(*N. J. State Hort. Soc.*)

Fig. 176. Apples packed in "flats" and arranged in banks produce a mass effect that is very pleasing for exhibit purposes.

plate 8 inches in diameter is desirable unless the fruit is very large.

Place all specimens in the same order on every plate. For instance, the accepted method for displaying a plate of five apples is to put four apples with stems up on the plate and the other apple, stem end up, on top of the four, over the center of the plate and resting on all four apples. Pears are usually placed on one cheek, stems to the center of the plate, or with the fifth pear on top of the others.

Alignment. Place the plates in exact alignment on the table, and so that the fruit itself on the various plates is in alignment. To have the apples on one plate form a square, with one apple in the center, as the observer looks at them, and to have the apples on the next plate cornerwise or at an angle is poor alignment and not in the best of taste. Have the angles



(*N. Y. State College of Agr.*)

FIG. 177. This exhibit is arranged to give a pleasing effect. The fruit is on the same plane throughout, there is no crowding, and the alignment of plates is good. A more extensive bank of "flats" at the rear and plain drapery for the sides of the tables would improve the appearance of the exhibit.

of the fruit on the plates parallel with the angles of the table top. Do not crowd the plates on the table. Leave a small space between them, not in order that the background may be evident, but in order to make each plate stand out by itself as a picture in a frame.

Labels. A major offense in setting up a plate exhibit is to put the tag or label on top of the uppermost specimen on the plate. The observer sees not the fruit but a sea of tags that get between him and the things of interest. Large tags or tags of different colors put on the plates without order or plan may spoil an otherwise attractive display.

Use small white cards. Attach them directly to the plate by means of pins having clips at the top, instead of the usual head, to hold the cards. Put these cards in the same position on every plate so that they may be easily seen from the edges of the table but so that they do not protrude above the level of the fruit. A good plan is to place the card on the back edge of the plate with its long axis parallel to the long axis of the table.

Fig. 178. This fruit has been carefully selected, correctly arranged, and properly labeled. The result is pleasing.

The card should give the name of the variety and such other information as is required by the nature of the exhibit. The locality or section from which the fruit comes has real educational value and interest. The grower's name is also desirable unless the fruit is entered for competition. In such case the name should be inserted after the judging is completed.

Tags giving merely the entry number or other classification in common use at fairs and competitive displays are meaningless to the general public.

Put all plates of the same variety together where possible, following an alphabetical arrangement. This makes it easy to find varieties and to compare different plates of the same variety.

Commercial Packages. Commercial packages must be of the nature required by commercial practice and by the rules. The same general principles governing plate exhibits also apply to them. A very effective exhibit device is the box flat. This is an apple box cut down so as to hold one layer of fruit. Arranged in banks, with colors and designs carefully worked out, these flats are exceedingly attractive.

Polishing Fruit. Polishing the specimens with a dry cloth gives them a glossier finish than they possess in their natural state. Many feel that the fruit should not be polished any more than it should be peeled, since the bloom is a part of the

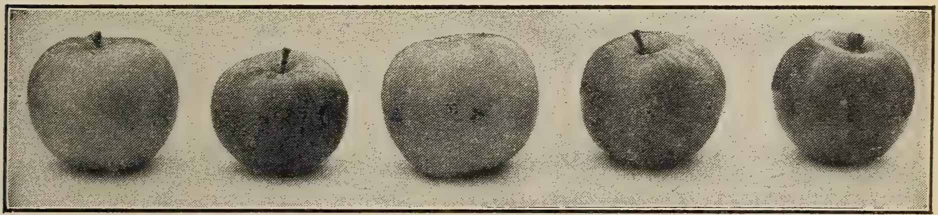


FIG. 179. Each of these Baldwin apples shown on the same plate is a good apple in itself, but the specimens are so diverse as to size, shape, color, and length of stems as to make the plate of no value in a competitive exhibit.

natural product. However, unpolished fruit may be at a disadvantage in competition with that which has been polished. The matter should be covered in the rules governing the exhibition.

3. Judging Fruits. Five specimens of apples, pears, peaches, and quinces, and three clusters of grapes constitute a plate at most exhibitions. Plums and cherries sufficient to cover an 8-inch plate are usually required. The smaller fruits, as berries, are usually exhibited in small packages as pint boxes.

For plate exhibits of tree fruits the American Society for Horticultural Science has promulgated rules and score cards which are now generally accepted and used.

The score card is:

Form	15
Size	15
Color	20
Uniformity	20
Condition	30
	100

Thus a perfect plate would score 100 points. The terms relate to the following:

Form. Typical of the variety.
Size. The most acceptable commercial size.

The American Society for Horticultural Science has promulgated certain sizes as being acceptable for the different varieties of apples. These sizes are:

Variety	Diameter in Inches	Variety	Diameter in Inches
Arkansas	3 to 3½	Rome	3 to 3½
Baldwin	2¾ to 3⅜	Roxbury	2⅞ to 3¼
Ben Davis	2¾ to 3¼	Stark	3 to 3⅜
Delicious	2⅞ to 3¼	Stayman Winesap	3 to 3⅜
Esopus	3 to 3½	Tompkins King	3¼ to 3¾
Grimes	2¾ to 3¼	Wagener	2¾ to 3⅜
Hubbardston	2¾ to 3¼	Wealthy	2¾ to 3¼
Jonathan	2¾ to 3	Williams	2⅝ to 2⅞
King David	2¾ to 3¼	Winesap	2¾ to 3
McIntosh	2¾ to 3½	Winter Banana	3⅛ to 3½
Northern Spy	3⅛ to 3½	Yellow Bellflower	3 to 3¼
Northwestern Greening	3¼ to 3¾	Yellow Newtown	2⅞ to 3⅛
Rhode Island Greening	3 to 3⅜	York Imperial	3⅛ to 3⅜

Allowance must also be made for sectional influences. A New England Jonathan would be considerably smaller than one from Missouri or the Northwest.

The tendency of the inexperienced exhibitor is to select oversized specimens.

Since oversize specimens are usually not so well colored as somewhat smaller ones, it is generally a safe rule to select those that combine the largest size with the highest color.

Color. The most acceptable commercial color for the variety. Since in red varieties the public shows its preference for high color on nearly every occasion, it follows that pronounced color is important.

Russet or green varieties should be true to type.

Uniformity. All specimens on the plate should be uniform with respect to the other factors on the score card. Uniformity is of especial importance, because if it is lacking the plate receives a double cut. For instance, if the form of a specimen is off type, a cut is made under the heading of form and another cut is made under uniformity. This is really double jeopardy but is probably warranted by the importance of the factor. Exhibitors fail more often on the question of uniformity than on any other. It is easy to pick out one good specimen and not difficult to select one or two more like it. To secure five specimens, each the counterpart of all of the others, requires a degree of skill and nicety of judgment possessed by few and then only after long practice.

Condition. This relates to general physical condition and freedom from blemishes. In regard to the former, the fruit should be firm, not flabby. In order to determine condition it is not necessary to indent the flesh with thumb or fingers, the mark of a novice. Hold the specimen in the palm of the hand and exert a general pressure by closing the hand over it.

A committee of the American Society for Horticultural Science has arranged blemishes or defects in four groups, running from the more serious defects to those of lesser significance.* The extent or degree of the blemish is just as important as its exact nature.

* B. D. Drain, "Report of Committee on Standardizing Intercollegiate Fruit Judging," American Society for Horticultural Science, 1925.

Group I

Codling moth	Apple blotch
Soft rot (caused by *Penicillium expansum*)	Bitter rot
Railroad worm	Apple scab

Group II

Worm injury (various kinds as lesser apple worm)	Withering (including shop worn)
San José scale	Unhealed skin punctures
Storage scald	Unhealed growth cracks
	Red bug damage

Group III

Baldwin spot	Curculio damage
Jonathan spot	Black rot
Physiological breakdown	Sooty fungus
Water core	Cedar rust
Heavy bruise (skin not broken)	Over-ripe (slightly)

Group IV

Entire absence of stem	Slight spray russeting
New England fruit-spot (caused by *Phoma pomi*)	Small rub spots (caused by limbs and twigs)
Fruit spots (unidentified)	Slight russeting (cause unknown)
Small insect stings (healed)	Small packing bruises
Hail damage (slight)	Insect eggs (example, European red mite eggs)
Small red spots not caused by scale	

Another score card in use in some sections is:

Form	15
Size	15
Color	25
Condition	15
Freedom from blemish	30
	100

The factor of uniformity is not listed but is taken into account under the headings of form, size, and color. Condition relates to maturity and physical soundness; freedom from blemishes to mechanical injuries and those caused by insect or disease.

The standard score card for grapes is

Form of cluster	10
Size of cluster	15
Size of berry	10
Color	10
Uniformity	10
Firmness	5
Quality	20
Condition (including bloom and blemishes)	20
	100

For commercial packs of apples and pears in boxes, the following score card was adopted by the American Society for Horticultural Science:

Fruit		
Texture and flavor	100	
Size and form	100	
Color	150	
Uniformity	150	
Freedom from blemishes	150	
		650
Box		
Material	30	
Marking	10	
Solidity (nails, cleats, etc.)	10	
		50
Pack		
Bulge	100	
Alignment	20	
Height of ends	60	
Attractiveness and style	40	
Compactness	80	
		300
Total		1000

Score Cards for Collections

(*a*) With specified number of plates:

Value of varieties for purpose stated	50	
Fruit (average of individual plate scores)	50	
Total		100

(*b*) Largest and best collection:

Number of varieties	100	
Value of varieties for purposes stated	100	
Fruit (average of individual plate scores)	100	
Total		300

A score card for baskets and hampers has not been worked out as carefully as for other packages. The following is suggested:

Package (appearance and workmanship)	15
Bulge or height of pack including compactness	15
Fruit:	
Form	10
Size	10
Color	20
Condition (including blemishes)	30
	100

Use of Score Card. The exact score of a plate or package is usually of less importance than its relative rank when compared with other plates or packages. One judge may cut or score much more heavily than another; yet if both are consistent the final ranking or order of placement will be the same. The use of the score card for a time impresses the relative importance of the different items so that the user unconsciously takes the different points into consideration in ranking the exhibits in later work, even though the score card may not actually be used.

It is usually best to do the judging in the comparative sense. Certain entries may usually be eliminated without taking the time to apply the score-card method, because it may be seen at a glance that they are outclassed.

In using the score card, make cuts on a percentage basis. Unless this is done, the mind, tending to deal with whole numbers, will make too heavy cuts on the less important factors on the score card and too moderate cuts on the more important factors. Thus, in the usual score card for apples, a cut of two points on size is a 20 percent cut, while a cut of two points on color is less than 10 percent.

How to Identify Varieties of Fruit. It is a valuable asset to be able to identify the major varieties of the various fruits. It is difficult to put forth a formula by which this ability may be acquired. Some of the most accurate judges have difficulty in explaining just how they recognize varieties. Much, however, can be accomplished in this direction by study. The suggestions given apply directly to the apple but may be adapted to other fruits.

Begin with a small number of varieties. Secure specimens from different regions in order that local variations may not mislead. Study these varieties several times a week throughout the season. Increase the list as knowledge increases.

Look for the constant external factors. Shape is much more reliable as a guide than size or color. The length of the stem and the depth of the cavity in which it is placed; the size and appearance of the dots that stand out in the skin on close inspection; the way the color is laid on, whether in stripes, splashes, a blush on the cheek, or in a solid effect; the depth of the basin or depression at the blossom end, whether the sides of the depression are straight or sloping; the calyx lobes, whether open and spreading, or closed and folded over each other—all are points that have bearing and tell their story to the person who studies them. Likewise, unusual corrugations or enlargement, such as appear characteristically about the calyx of Delicious, or suture lines running from stem to calyx over the outer surface as in Tolman or Winter Banana, are significant.

Some of these characteristics may be off type in a specimen, but it is seldom that all or any large number of them will be misleading. To safeguard the situation further, judgment should be based on several specimens rather than on a single one.

Interior characters are also significant when they can be determined. These relate to color of the flesh, colored threads extending to the core, size and shape of core lines and their manner of union with the calyx tube, position of core on the axis from stem to calyx, number of seeds, size of seeds, size and shape of pits, etc. The flavor and the juiciness of the flesh in fruit that approaches eating condition are leading factors. However, most of the work of identification and judging for general purposes is done with reference to external characters, either in tree or small fruits. External factors then should be studied with thoroughness and accuracy.

Many identification keys or classifications have been developed by various individuals, but none of them as yet is infallible or even very satisfactory for variety identification.

Part II

GROWING SMALL FRUITS

The term "small fruits" has come to be applied to the strawberry, the bush fruits, brambles, and sometimes the grape. So far as these fruits require distinct treatment, they are discussed separately in this section.

The turnover as compared with the tree fruits is much more rapid; one may go into or out of the business quickly. These fruits, with proper attention to variety adaptations, may be and are grown over wide areas and, especially the strawberry, under divergent climatic conditions. Many of the small fruits are highly perishable and must be harvested and consumed within narrow time limits. Although this is a disadvantage in some respects, it gives the opportunity to develop local areas to meet local demands with satisfactory returns up to the normal requirements of the community. Larger producing sections must, of course, find their outlets on the general market. In either event, an adequate labor supply must be immediately available when the fruit is ready to harvest.

Before deciding what fruits to grow or where to grow them, consult authoritative agencies in the section and the experience of successful growers.

CHAPTER XII

GROWING STRAWBERRIES

The strawberry is grown for home use in every state and in carlots for commercial purposes in three-fourths of the states of the Union. It is at home throughout all the country east of the Missouri River, in the South, and on the Pacific Coast. See Table 49.

Operations:

1. Selecting the location and soil.
2. Preparing the field.
3. Selecting varieties.
4. Determining time of planting.
5. Determining the planting system.
6. Setting the plants.
7. Managing the soil.
8. Controlling insects and diseases.
9. Protecting plants in winter.
10. Harvesting and marketing the crop.
11. Determining treatment of plantation after harvesting.

1. Selecting the Location and Soil. Earliness of ripening is usually important. Sandy or gravelly soils and those with a slope giving the maximum of sunshine help in this regard. Loams with a good moisture supply will yield more heavily, with maturity somewhat delayed, than lighter and drier soils. Sandy or gravelly loams underlain with clay, that are retentive of moisture but loose enough for drainage and easy tillage, are desirable. Soils with high clay content are likely to cause loss through freezing and "heaving" in the colder sec-

TABLE 49

STRAWBERRIES—COMMERCIAL*

Group and State	Acreage			Yield per Acre		
	10-Year Acreage 1928–37	1938	1939	10-Yr. Av. 1928–37	1938	1939
	Acres	*Acres*	*Acres*	*Crates*†	*Crates*†	*Crates*†
Early:						
Alabama	4,050	3,300	3,600	75	74	85
Florida	8,120	7,500	9,000	68	70	85
Louisiana	20,210	22,000	20,000	65	50	70
Mississippi	880	360	350	53	60	65
Texas	2,360	1,950	1,900	56	60	57
Group total or average	35,620	35,110	34,850	65.3	57.2	74.7
Second early:						
Arkansas	19,370	14,100	16,900	41	60	52
Calif., S. dist.	1,700	1,800	2,100	186	175	156
Georgia	490	400	250	52	60	75
N. Carolina	7,910	7,200	7,900	80	52	64
S. Carolina	510	250	300	70	60	75
Tennessee	16,530	15,600	17,000	47	45	50
Virginia	6,610	7,300	7,700	78	70	68
Group total or average	53,120	46,650	52,150	58.5	59.7	60.0
Intermediate:						
Calif., other	2,840	3,230	3,320	196	160	164
Delaware	4,480	5,200	5,000	57	45	45
Illinois	4,910	6,200	6,700	52	50	65
Kansas	1,160	1,100	1,300	45	50	45
Kentucky	6,870	7,700	8,900	55	55	60
Maryland	7,540	8,100	7,900	67	55	60
Missouri	12,110	9,000	13,500	38	60	35
New Jersey	3,710	3,400	4,000	83	100	70
Oklahoma	1,620	400	900	32	60	45
Group total or average	45,240	44,330	51,520	62.5	65.2	59.5
Late:						
Indiana	2,560	3,100	4,000	67	80	80
Iowa	1,640	800	900	54	60	75
Michigan	9,380	11,600	13,000	63	40	105
New York	3,600	3,900	4,300	75	80	85
Ohio	3,820	4,500	4,900	61	75	90
Oregon	10,920	13,400	12,200	66	78	85
Pennsylvania	3,810	4,800	4,800	68	70	85
Utah	1,240	1,400	1,300	63	60	65
Washington	7,660	7,700	7,500	71	78	71
Wisconsin	1,820	2,500	3,000	49	80	70
Group total or average	46,450	53,700	55,900	66.1	68.5	86.4
Total, all states	180,430	179,790	194,420	62.8	63.2	70.1

* Includes undetermined quantities used for processing.

† Crate (24 quarts) containing approximately 36 pounds.

tions, the strawberry plant being shallow-rooted with none too firm a hold on the soil.

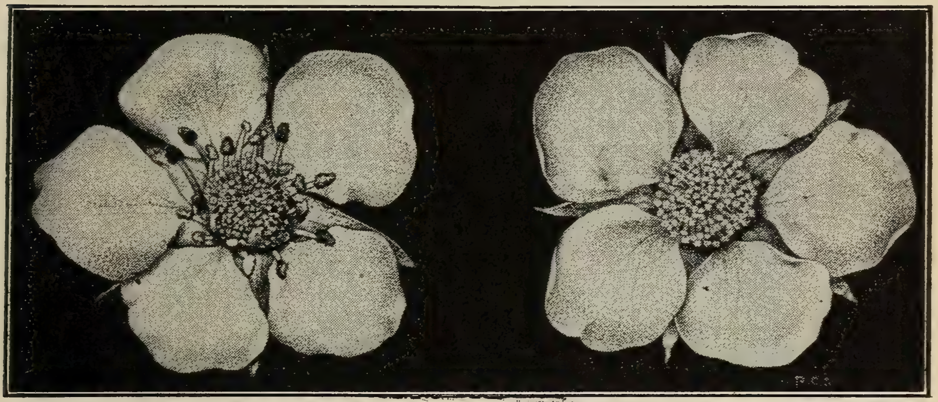
Under conditions where the market justifies the expense, dry soils made rich in organic content may be utilized through the installation of artificial irrigation. More than most fruits, the strawberry reflects insufficient moisture supply at the ripening stage in small individual fruits and reduced total yield.

The strawberry blooms early. In sections where spring frosts are a factor, guard against loss by planting on areas insuring air drainage. Avoid wind-swept areas in the colder latitudes so that the plants may be protected in winter by a mantle of snow.

2. Preparing the Field. Begin preparations at least one year in advance. A cultivated crop is usually best to precede planting. It is important that this crop shall be kept clean so that the land may be free of weeds and grass before the strawberries are set. Land in sod harbors the white grub or larva of the May beetle, often seriously destructive. If grubs are present in large numbers, cultivated crops should be grown for two years before setting. Freshly cleared stump land often gives good results, if free from roots and sprouts. In the South, select land free from the root knot nematode or practice a three-year rotation of crops that are not subject to its attacks.

Make the soil rich. Stable manure is unexcelled for this purpose, but unless well rotted it should be applied to the preceding crop so that weeds may be killed. In many sections it is practically impossible to secure manure. In other sections where it can be secured, the quality is often very poor and it is sometimes full of weed seeds. In such regions growers have practically discontinued its use and plan to plow under green manure crops instead. Bring the land to a high state of tilth before planting.

3. Selecting Varieties. Plant varieties with a record of success in the region. Try others, no matter how well advertised or recommended, with care. Although the strawberry may be grown over wide areas under varying conditions, this is not generally true of its varieties. Results may differ within a radius of a few miles. Varieties with firm flesh must be selected if the market to be served necessitates shipment. Some varieties of good quality are poor plant makers and return low yields unless this fact is recognized by closer planting than ordinary, and then the difference frequently cannot be entirely overcome. In some sections late varieties find the market in better condition than early or mid-season kinds,



(U. S. D. A.)

Fig. 180. The blossom at the left is perfect, possessing both stamens and pistils; the one at the right is pistillate or imperfect, having pistils only.

which are subject to greater competition. Take account of these factors before making up the variety list.

Keep in mind also that some varieties possess perfect flowers, including stamens and pistils; other varieties produce flowers with pistils only, or with stamens that are abortive (Fig. 180). The latter, planted by themselves and lacking pollination, fail to yield. If the first choice is a variety with imperfect flowers, select as second choice a perfect variety and plant it in every third or fourth row. There is evidence that some varieties with perfect flowers do better in unfavorable seasons if interplanted with others.

Some of the leading commercial varieties are listed under "General Information" at the close of the chapter.

4. Determining Time of Planting. Plant in early spring in all except southern United States. With proper care, this insures a full crop the next year. August or fall planting is possible and common in some sections, but experience indicates that it is a desirable practice only under special conditions. Losses from dry weather after planting, or from the oncoming winter, are more severe. A full crop cannot be

Fig. 181. Left, an old plant, undesirable for setting; right, a young plant with vigorous root system, desirable for setting.

expected the following season because the plants do not develop sufficiently before the cold weather to give a wide and well-filled row. Greater difficulty is experienced in keeping the plantation clean until full fruitage.

Only well-grown plants with strong, fibrous root systems are worth planting (Figs. 181, 182). There is more difference between strawberry plants than the public seems to realize. Many taken from old beds and those from some nurseries are not worth setting. Use plants which developed the previous season, unless planting in late summer or fall, when plants of the current season's growth are preferable. Older plants are lacking in vigor and do not freely develop runners and new plants.

5. Determining the Planting System. The *matted row* is the prevailing planting system in the Eastern states for commercial purposes. In it hand labor is reduced to the minimum. Runners are permitted to develop from the mother

(*U. S. D. A.*)

Fig. 182. Good plants of different varieties showing differences in root growth and size. Klondike at left, Dunlop at right.

plants at will so that by the end of the season a solid row from 1 to 2 feet wide, or sometimes more, has formed (Figs. 183, 184). Rows 4 feet apart with plants 15 to 24 inches apart in the row represent average practice, variations therefrom being determined by local conditions and experience. A sparse plant maker like Chesapeake should be planted more closely than a profuse plant maker like Aroma. Gandy is planted from 18 to 24 inches apart in the row, whereas Catskill is usually spaced 40 inches.

A space between rows should be retained in which the pickers may walk. There is danger also of having the rows so wide that ripe berries in the centers are overlooked. By having the pickers pick from each side to the center of the row this difficulty is reduced but not entirely eliminated, since workers will not reach in to pick the centers as carefully as where the rows are narrow.

Fig. 183. The beginning of the matted row; mother plants in the center. The soil must be kept loose so that the runner plants may root readily. See Fig. 184.

In dry seasons, owing to the competition between plants for moisture, the berries may run small. On the other hand, under this system a full stand is almost certain, for, although some mother plants may be lost and the last runners to develop may kill out, there are sufficient remaining to give an even stand. The total yield over a period of years will be greater under the matted row system than any other.

Modifications of this system are known as *hedge rows*. The new plants are spaced according to a definite plan and extra runners and plants are removed. Good results may be obtained, but the amount of hand labor is increased.

The *hill* system is used extensively in Oregon, Washington, and the far South. It is used to some extent in all sections for the home garden. Plants are spaced 12 to 15 inches apart in all directions, or a greater distance may be allowed between rows on areas large enough to permit horse cultivation. All runners are removed, and the mother plants make a very vigorous development, reflected in a crop of uniformly large fruit. This system of planting is well adapted to the pro-

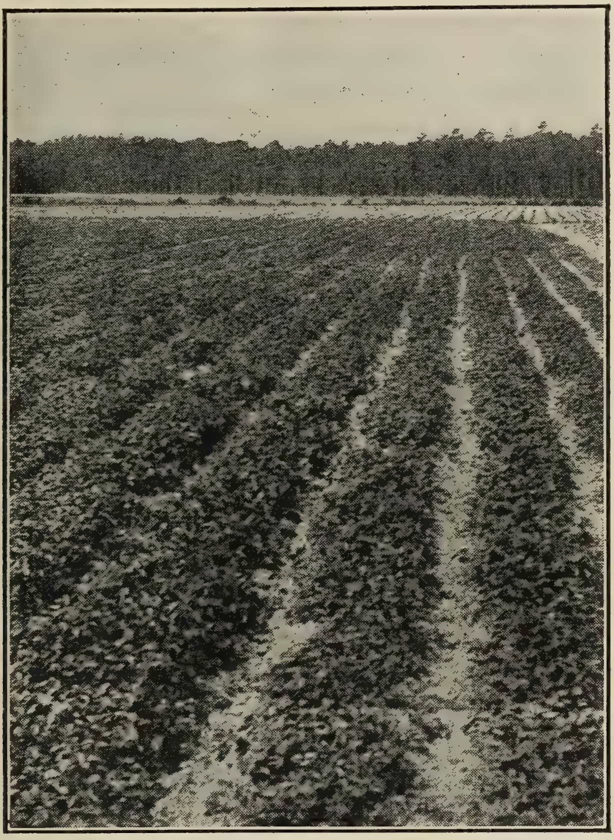


Fig. 184. The matted row system fully developed.

duction of fruit for a fancy trade. Considerable attention is required the first season to restrict the runners. If the mother plants die, vacant spaces occur in the row.

6. Setting the Plants. After the location of the first or outside row has been determined, use markers, either hand or horse drawn, depending upon the area, to complete laying out the field. Such markers are quickly made—a horizontal piece with holes bored at proper distances to take the legs or markers, a pair of shafts for the horse or mule, and some handles extending behind so that the operator may keep the implement steady. Extra holes may be bored in the bed piece and the legs made removable to permit changing the distances. The persons who do the planting gage distances between plants

(*U. S. D. A.*)

Fig. 185. If the plants must be held before setting open the bundle, spread the plants singly along the side of the trench, and throw the soil back, pressing it firmly against the roots.

in the row accurately, and usually cross-marking is not necessary.

Set the plants firmly, at the proper depth and when the soil is moist. Any planting method that takes account of these factors will give good results. It follows, therefore, that the plan which safeguards the situation in these respects and which is most economical under the conditions that must be met is the plan to adopt.

Set the crown at ground level. Below ground level it is likely to smother and growth will certainly be retarded; above ground level, the roots are exposed and will either die or be seriously injured (Fig. 186).

Remove a few of the outer and older leaves before planting if this has not already been done. Such leaves will have been removed from nursery plants before shipment. If the grower obtains his plants from a bed or field, he should remove these leaves as the plants are dug. If the roots are long and straggling, clip slightly to aid in planting.

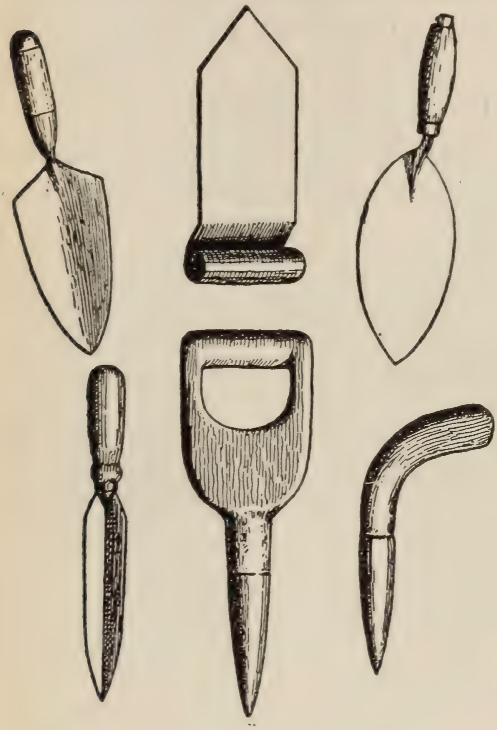
With its root system of many fibers, it is easy to set the plant loosely even when intentions are the best. A circular

(U. S. D. A.)

Fig. 186. The plant at the left has not been set deeply enough, the entire crown and the top of the root system are exposed; the center plant has been set at the proper depth; the plant at the right has been set at too great a depth.

hole such as is made by a round dibble (Fig. 187) does not permit shaking and spreading the roots but crowds them together, resulting in a minimum of contact with the soil. Plants thus set may live in a good season, but if it is dry after planting, the chances are against them. In any event they will not make the development that may be expected from plants properly set.

The flat and pointed trowel of various designs is a good planting tool (Fig. 187). Press it into the soil to the desired depth, work it back and forth, withdraw, insert the plant, shaking the roots apart in a fan shape, and press firmly in place. Two men or a man and boy will do this better than one person. It is well to have a boy carry a bucket full of plants, keeping the roots wet and dropping them just as needed. A variation of the method is for the person who carries the plants to press the soil about them with his foot after they are in place.



(*U. S. D. A.*)

FIG. 187. Types of tools used in transplanting. The two tools at the lower right make round holes, giving little opportunity to shake and spread out the roots when inserting them in the soil.

The spade is widely used instead of the trowel, as it saves some bending over. The procedure is the same and, under good conditions, makes rapid setting possible.

Setting is sometimes done with a paddle, or with a punch and tongs used in sweet potato planting. Some growers prefer a short-handled hoelike tool.

On level land, cabbage or tomato planters, skillfully operated so as to set plants at the correct depth, have given satisfaction.

A patent planter operated by hand, which waters the plants if necessary at planting, is now on the market. Its introducers claim that it has given excellent results and that it is much more rapid than hand planting. The fibrous root system of the strawberry makes it more difficult to set by mechanical devices than a plant with a single large root.

The operator must determine the method best suited to the circumstances. There is always the opportunity for the exercise of individual judgment. Whatever the planting method pursued, remove all large leaves, and protect the roots carefully from wind and sun.

It is probable that starter or nutrient solutions now used in transplanting vegetables would aid in getting the plants off to a quick start. This should prove very important in application to strawberries since the early-formed runners are much more productive than those formed later in the season. Watch for further announcements from the experiment stations.

7. Managing the Soil.

Procedure:

(*a*) Cultivating the soil.
(*b*) Fertilizing the plants.
(*c*) Shall irrigation be practiced?

(*a*) *Cultivating the Soil.* Cultivate frequently for best results. Not only does this keep down weeds and grass and conserve moisture, but the new plants formed on the runners establish themselves much more quickly in a loose soil than in one that is hard and baked. Do all cultivation possible by horse or tractor power. Most of it can be done this way if directions for treatment of the field previous to planting have been followed. The hand hoe, however, cannot be entirely discarded. A wheel hoe is useful, especially under the hill system of management. Rolling cutters on the cultivator help to limit the width of the matted rows. The plants have shallow roots. The first cultivation may be deep, but later cultivations close to the plants must be shallow. Adjust the outer cultivator teeth with this in mind. In many regions, care is taken during the first summer while hoeing the bed to space the young plants at regular intervals so that uniform matted rows are obtained.

Cultivate up to late fall to discourage the weeds that appear even late in the season and to keep the plants growing.

Remove the first blossom stalks, as the formation of fruit soon after setting taxes the vitality of the plant severely.

After the field is well established, it is not worth while to attempt to remove the relatively few blossoms that appear.

(*b*) *Fertilizing the Plants.* Stable manure, when it can be secured at a reasonable price and when it does not contain too many weed seeds, is a very valuable fertilizer. From 15 to 20 tons per acre should be applied, preferably to a preceding cultivated crop. Where stable manure cannot be obtained or where its use is questionable, green manure crops should always be turned under before planting strawberries. Rye, cowpeas, soy beans, and the clovers are good green manure crops. The decaying organic matter of the stable manure and green manure not only adds humus and plant food but also improves the mechanical condition and moisture-holding capacity of the soil. These last two factors are especially important in strawberry growing.

In addition to the stable or green manures, it has generally been found profitable to add liberal amounts of commercial fertilizers in most growing regions.

Of the three fertilizer elements usually applied—nitrogen, phosphorus, and potassium—the addition of phosphorus has seemed to be needed in most regions more than the other elements. The need of additional nitrogen in some regions is marked; in others no value can be seen from applying this material, or, at least, its use in view of its cost and the cost of application of the material is questionable. The value of applying potash in many regions is very questionable. The need for its application has not been as clearly shown as for phosphorus and nitrogen, except on the lighter soils of the South.

During the first year, phosphoric acid and some nitrogen seem especially desirable for causing good growth, numerous plants, and strong healthy crowns. Potash in addition may be of value in light, sandy soils. An application of a quickly available nitrogen fertilizer, just before blossoming in the crop year, appears to be profitable in increasing the set of fruit and size of berries in light soils, but its use is questionable on the heavier soils. Wherever this quickly available nitrogen is used, certain detrimental results may occur, if applications are too heavy and especially if the early season is wet. Thus, too vigorous a growth of stems and leaves may occur, delaying the ripening of the crop and causing the berries to be soft and green. Such fruit carries very poorly if it is shipped long distances to market.

Fig. 188. Applying fertilizer during the growing season. After the application, a sack is dragged over the row to brush the fertilizer from the foliage.

When the practices of the best growers and recent experiment-station investigations are studied, it appears that, after provision is made for incorporating organic matter in the soil, fertilizers are often applied at three different times. These periods vary with the different regions. Fertilizers may be applied: (*a*) at time of planting; (*b*) during the first summer; and (*c*) just prior to blossoming in the fruiting season. In some regions, growers make only application (*a*), in others, (*a*) and (*c*), and in some sections all three. A total application of 1000 to 2000 pounds per acre is customary. Consult the findings of the local experiment station and study the practices of the better growers.

Some fertilizers, as nitrate of soda and muriate of potash, are caustic and should not be put in actual contact with the plants, unless the plants are dormant at the time of application. It is customary to apply fertilizers by hand (Fig. 188).

Strawberries seem to prefer an acid soil for best growth and production. Ordinarily, therefore, the addition of lime would be detrimental. However, different growers and investigators have found that strawberries are sometimes benefited by the addition of some lime on soils which are very acid. In other words, extreme acidity may sometimes be reduced, but the soil should still be left in an acid condition for the best results.

(*c*) Shall irrigation be practiced? In some of the commercial sections of the Far West the strawberry is grown commonly under irrigation. Frequently it is an intercrop in irrigated orchards.

Irrigated strawberry fields in the East are less common than on the Pacific Coast but are by no means unusual. Quite extensive irrigation projects occur in southern New Jersey, and small installations are generally distributed throughout the Northern states. Their use seems to be increasing.

The strawberry plant with its shallow root system is quickly affected by lack of moisture in the upper soil. The lighter soil types, on which this fruit is commonly grown, are naturally affected by drought more quickly than the heavier loams. Very frequently there is a lack of moisture at harvest time, especially for the pickings toward the end of the season. This causes the fruit to run small and materially reduces the yield. In extreme cases the entire crop, representing a year's investment, may be ruined. The strawberry may suffer from lack of moisture at times other than the harvest season, limiting the formation of new plants and causing a poor stand in the rows.

In sections where the natural rainfall is sufficient in normal seasons, the use of irrigation is questionable. If the land may be used in rotation for growing other crops which give a high return per acre, and which also benefit from irrigation, such as truck and garden crops, then the argument for irrigation is strengthened.

If the grower possesses a market for large fancy fruit at an advance over current quotations, irrigation may be a profitable practice.

In any case, irrigation should not be made a substitute for thorough, intensive tillage. Only the best-grown fields are likely to justify the added investment.

In the West the furrow system is common. In the East, the overhead system is commonly employed; it calls for much the greater investment in pipes, fittings, etc. The furrow system cannot be used on steep and irregular lands and functions

(*W. F. Allen Co.*)

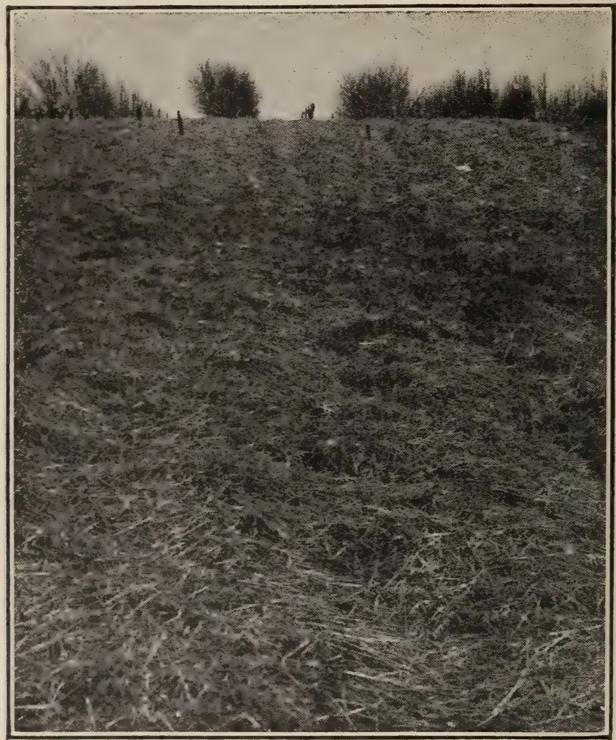
Fig. 189. A field of Dorset grown in Maryland by the matted row system.

best on rather heavy soils not subject to washing. In either system an accessible and ample water supply is a necessity.

Irrigation is usually practiced after each picking unless the natural moisture supply is adequate. The heavier applications are made late in the season when the fruit naturally begins to run small. Applications may be advisable at other times throughout the growing season, especially for everbearing varieties.

8. Controlling Insects and Diseases. Since strawberries occupy the land for short periods, in many cases only one crop being harvested, it is natural that control measures should turn as far as possible on clean tillage and crop rotation. The disease and insect problem is therefore not likely to become as serious a factor as in fruit plantations that occupy the same ground for years.

Follow the control program of the local experimental sta-



(*Mo. Exp. Sta.*)

Fig. 190. A field of strawberries mulched with clean straw.

tion, the United States Department of Agriculture, and the methods of experienced growers.

9. Protecting the Plants in Winter. Mulching the rows in cold weather is good practice where material is available (Fig. 190). Do it as soon as possible after the ground first freezes in the fall. The purpose is not to shield the plants from cold, but to reduce to a minimum alternate freezing and thawing of the soil, which loosens the roots.

Mulching is most necessary in wind-swept locations, or on heavy soils, or in latitudes where the snowfall is light and where freezing of the soil followed by warm days is a frequent occurrence. By delaying slightly the removal of the mulch in the spring, blossoming may be retarded in sections where frosts are a factor.

Any material free from seeds that does not mat down too closely and yet that is not too coarse to defeat its purpose will do. The choice will be determined by availability and cost. Marsh or swale grass, straw, coarse manure, and pine needles are all serviceable. Cornstalks are rather coarse but help to hold the snow and are of value. The beginner is likely to apply a heavier mulch than is necessary. A depth of 2 to 3 inches of the loose material is sufficient.

Rake or fork off the mulch after freezing of the ground is no longer a factor in the spring and in any case before the leaves turn yellow. Much of the material will have settled about the crowns. Leave as much of this as possible to keep the soil moist and to prevent muddy and soiled berries at picking time. That which is raked off may remain between the rows, or, if such material is scarce, it may be hauled off and stored for use another year.

Oats or barley, sown in late summer between the rows, may contribute a partial mulch, as they go down with the first frost. However, it is possible that the loss through discontinuing cultivation at so early a date is greater than the gain from the mulch.

10. Harvesting and Marketing the Crop. The second season brings the main harvest, if the field was set the spring of the preceding year. Thus plants set in March or April one year will fruit heaviest in May or June of the next year. Ordinarily, no cultivation is given the second spring until after harvest. Weeds and grass may be pulled or hoed out, but if thorough tillage was given during the preceding season there will be little trouble on this score.

The quart basket and the 24- or 32-quart crate are commonly used. Attractive paper-board quart boxes waxed and lithographed, with slits in the sides for ventilation, are now available. Pint baskets are also used to a limited extent.

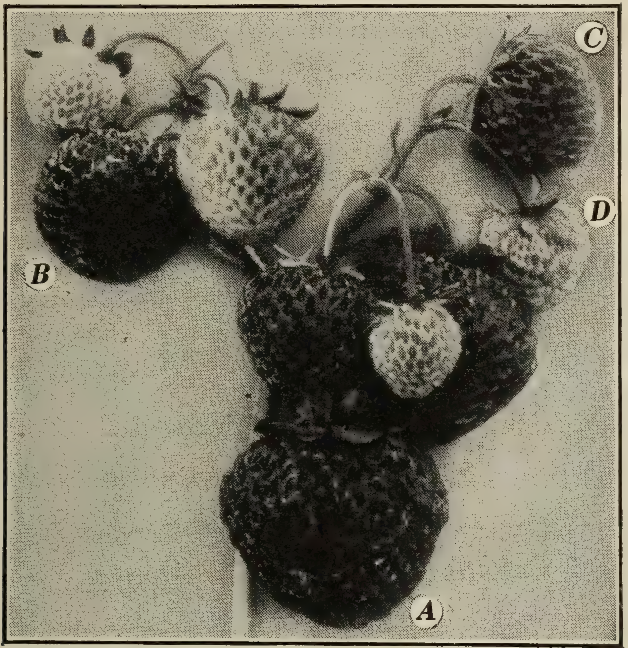
No general directions as to stage of maturity for picking can be given; it depends on the variety and the distance to market. A variety should seldom be picked with the tips still green. Soft-fleshed varieties must be picked while still firm,

(*W. F. Allen Co.*)

FIG. 191. The promise of a good crop. The row is full of strong plants, and the plants are full of blossoms.

unless for local consumption. Pick the fruit as soon as it is dry in the early part of the day and at as cool a temperature as possible. It should be marketed, or sent on its way to market, the same day. For local market some growers have found it best to pick in the afternoon, keep the berries in a cool place over night, and deliver early in the morning.

Pinch the stem rather than the fruit, and leave the hulls on the berries. Pickers should be equipped with carriers holding four to six baskets. Handle the fruit as little as possible and keep it out of the sun. For these reasons also, larger carriers should not be used. For some trades it will pay to face the baskets, turning the berries on their sides with as little of the



(*G. M. Darrow, Fruits and Gardens, June, 1928*)

FIG. 192. "A fruit cluster showing the relative size of berries borne in different positions on a cluster. The primary berry at *A* ripens first and is the largest; the secondary berries at *B* ripen second and are next in size; the tertiary berries at *C* are much smaller than the secondary while the quaternary berries at *D* are still smaller. Because the berries on any cluster are progressively smaller, the later berries to ripen are the smallest and the crop is said to 'run down' in size."

hull showing as possible. Remove all soiled berries and "nubbins" or undersized fruit from the first grade. Fill the baskets well above the tops to allow for settling, especially when shipping to market. Ventilated or iced cars will be necessary, depending upon the time in transit. The crates must be well braced and arranged to permit free air circulation.

Shipments in less than carlots to distant markets are made from the West and South in heavy refrigerator boxes holding 64 to 80 quarts. These are known as pony refrigerators and are returned to the shipper. The ice compartments are filled before shipping.

The strawberry may be held for a short time in cold storage —apparently as long as a week or ten days if only firm berries

(*W. F. Allen Co.*)

FIG. 193. This crate of berries will sell at the top price in any market.

are used, and if they are rushed to storage immediately after picking. The proper holding temperature is 30° to 32° F. The holding time is not long, but it may carry the fruit past a glutted market.

For use by preservers, as crushed fruit and syrups for soda fountains, the uncooked berries, hulled, washed, and treated with sugar, are held in casks in cold storage at a temperature of 30° F. or lower. Consult "Frozen Fruit," page 148, for further information on modern methods of freezing.

Yields. Yields of fruit vary greatly, depending on the general vigor of the plantation, the variety, and the season, including possible losses from frost injury at blossoming time and the supply of moisture. A production of 100 crates or 3200 quarts per acre in New York is too low on the average for a profit. However, in many other regions with cheaper labor costs a profit can be made on this yield. Consult Table 49, page 469, for average yields in the various sections. The successful grower must secure yields substantially higher than these. Many growers secure 5000 to 6000 quarts per

(*W. F. Allen Co.*)

Fig. 194. A field stand in Maryland. The picked fruit must be kept out of the sun.

acre; and much higher yields, especially under irrigation, are frequently obtained.

11. Determining Treatment of Plantation after Harvest. The grower must decide whether he will pick more than one crop from his planting. The answer calls for individual judgment based on known facts. The investment in plants and planting has already been made. If the field is reasonably free from grass and weeds and if the plants are strong, the plantation may be retained for another season, or possibly more. The procedure follows: After picking, mow off the tops of the plants; rake the refuse into winrows, and remove it. If not abundant, the refuse may be raked between the rows and plowed under. If the field has been affected with leaf spot or other fungus troubles, the material may be burned on the field in a stiff wind so that the fire travels quickly down the rows. Do not attempt to burn the material when the soil is excessively dry or when the leaves are damp, as injury to the plants will follow.

Plow back the sides of the rows to leave strips 10 to 15 inches wide, depending upon the freedom with which the

Fig. 195. A common scene in strawberry season in southern producing sections. The grower brings his offering to an auction shed where the fruit is inspected and buyers bid for it.

variety forms new plants. By plowing one side of the row only, back to and beyond the original mother plants, the strip remaining will be composed of young and vigorous plants.

Finish with cultivator, smoothing harrow, and hand hoe, thinning the plants rather severely but allowing more to remain than in the original planting, since runners will not form so freely as in the first year. An application of well-rotted stable manure or of high-grade commercial fertilizer should be made at this time. Some growers simply work up the ground between the rows and then thin out the plants.

In many parts of the South the old bed is plowed under immediately after picking, and a crop of cow peas is grown and plowed under in late July. Rye or crimson clover is then seeded, and this is plowed under before planting to strawberries again the following spring. Thus, two crops of green manure are plowed under before replanting the field to strawberries. If chickweed is abundant, the rye or clover crop is not grown, but the ground is kept cultivated through the late summer and fall to eradicate this troublesome weed.

GENERAL INFORMATION

I. Everbearing Varieties

Everbearing varieties are now well known. The term is somewhat misleading but is in common use. Such varieties bear at the usual time, followed by a period of low production or absolute cessation of production. In late August and throughout the fall, another crop follows, if growing conditions are favorable.

It should be kept in mind that many varieties of strawberries, given exactly the right conditions of soil and climate, may produce late in the season without warranting designation as everbearing varieties.

Everbearing varieties as a rule need a very fertile soil to give them size and to provide their rather exacting moisture requirements. Planting may be according to the hill or matted row systems, depending largely upon the freedom with which the varieties form runners. General culture is as indicated for ordinary kinds. The first flower stems should be removed if practicable. The best berries will be obtained the first fall, and many fields are kept only one season. The second-season fruit is borne at the normal time, followed by a rest period and then by further bearing, but the fruit tends to be small, both as to size and total yield.

It cannot be claimed that everbearing varieties are profitable for the general market. They have a place in the home garden, to meet a special or local demand, and for the sale of plants. They are especially valuable in the valleys of some Western states including Idaho, where late spring frosts often kill the blossoms of most varieties. In these valleys, the everbearing varieties are the chief kinds grown. Everbearing varieties well adapted to the far South have not been developed as yet.

Varieties

Gem. Most consistent producer of summer and fall berries, recommended for a home garden.

Champion (*Progressive*). Sweetest everbearer, berries are small but the plants are productive.

Green Mountain. Later berry, adapted to cool climate and heavy soil.

Mastodon. Vigorous productive plant; it is the most commonly grown everbearing variety, fruit is large, irregular in shape, and ships well.

II. Commercial Varieties

There are hundreds of varieties of strawberries. Many of them possess merit for certain purposes and in some sections. Included in the following list are those varieties which have assumed commercial importance in areas of greater or less extent, for general market use. It is not put forth as a complete list. New varieties appear and very rapidly come into prominence. The varieties that do well in Northern United States are, as a rule, adapted to Canada. Varieties have perfect flowers unless otherwise indicated.

Aroma. The leading commercial variety in a belt extending east from Missouri to Kentucky.

Belt (*William Belt*). Late variety, high quality, adapted to Northern states.

Big Joe. Fancy mid-season berry, especially large fruit, subject to frost injury, grown commercially in New Jersey and Delaware and to a less extent in Northern United States.

Blakemore. One of the finest berries of the South and as far north as Maryland and Virginia; it has proved to be a good shipping variety—productive, light red, firm, tart flavored.

Catskill. Standard variety in New England, New York, Ohio, and Pennsylvania. Vigorous, sturdy, hardy plant, good-quality fruit. It has been known to give higher yields than almost any other variety.

Chesapeake. Late season, large berry of unusual quality, not highly productive, grown largely in Northeastern United States.

Dorsett. A good early commercial strawberry, high quality, bright red fruit, large size and large cropper, grown chiefly in Northern states but popular as far south as Georgia.

Dresden. A new early berry which is adapted to New England, New York, Ohio, and Pennsylvania.

Fairfax. Noted for its high-quality fruit, very large yields of large berries, and firm berry, but its color darkens after it is picked; grown chiefly in Virginia, Kentucky, Missouri, and in states farther north.

Gandy. Delaware, Maryland, and much of Northern United States. Late berry which likes low ground or irrigation.

Gibson (*Parsons Beauty*). Very productive, very good quality, an old berry which stands up well against many new varieties; grown chiefly in Michigan, Ohio, New York, and Ontario.

Glen Mary (*partially imperfect*). New York, New England, Ontario, and other sections of Canada; highly productive but poor-quality fruit.

Klondyke. Leading berry in parts of Gulf Coast and South Atlantic states.

Lupton. Late shipping berry, poor flavor, grows well with heavy fertilization; grown largely in New Jersey, Delaware, and eastern Maryland.

Missionary. The standard market variety of central Florida; grown largely also in eastern North Carolina, the Norfolk Section of Virginia, and eastern Maryland.

New York. Grown under many synonyms, very sweet fruit; popular in Northeastern states.

Premier (*Howard*). One of the leading varieties, especially in New England, south to Virginia and west to Illinois; early cropper, frost resistant, large yielder; even-sized, good-appearing fruit, of good quality and firm, but flavor is not so good as that of some varieties.

Sample (*imperfect*). New England and westward to Michigan and Illinois.

Senator Dunlap. Northern half of area, east of Rocky Mountains; old variety, good quality, medium size.

Wilson. Grown to a limited extent in western New York and in Oregon and Washington.

COMMUNITY STUDIES

1. Visit five or more of the leading growers of the community, including at least one grower selling at a roadside stand.

Determine:

a. Market served.
b. Acreage.
c. Location with respect to slope and site.
d. Type of soil.
e. Varieties, cost of plants, and source from which obtained.

f. Treatment of field for two years before planting.
g. Preparation of field for planting.
h. Time of planting.
i. System of planting used and number of plants per acre.
j. Method of planting.
k. Subsequent cultivation and care.
l. Harvesting plan—source of help.
m. Costs of packages.
n. Wages—day or piece rate; bonus.
o. How fruit is delivered and costs of delivery.
p. Average yields by varieties if possible.
q. Average selling price for several years.
r. Number of crops picked from one planting.
s. Treatment of field after picking.
t. Winter treatment.
u. Fertilizers—kind, rate, cost, time and method of application.

2. With the foregoing information, prepare an outline including all necessary operations, costs, yields, and net returns on a field sufficient:
a. To supply the usual needs of a village of 2000 persons (determine requirements from local growers and fruit merchants).
b. To permit shipment of carlots of a single variety to the general market.

CHAPTER XIII

GROWING GRAPES

The American grape is grown over a wide range for home use. It is a commercial product as table fruit and for grape-juice and other by-products in several large but definitely limited areas in New York, Pennsylvania, Ohio, Michigan and in the Province of Ontario, Canada. It is also grown commercially in smaller local regions where conditions are satisfactory, in states west to Missouri and south to North Carolina and in the elevated sections of Georgia and Alabama. See Table 50.

The term "American grape" refers to the native grape or its hybrids with the European. The European is the one grown in California, *Vitis vinifera,* of which many varieties have been developed. There are many native species, but the wild fox grape, *Vitis labrusca,* is responsible either directly or through crossing with *Vinifera* for the grape as it is known in most of the country. In the warmer parts of the South, chiefly on the coastal plains, Muscadine grapes of species *Rotundifolia,* of several colors, with such varieties as Scuppernong, Thomas, and James, are mostly grown.

The authors are not dealing with the California grape, since its culture represents a separate and highly specialized enterprise in a restricted area. Culture of Muscadine grapes, so far as it differs from the Labrusca or bunch grapes, is indicated at the close of this chapter.

Operations:

1. Determining the size of the enterprise.
2. Selecting the location.

TABLE 50

GRAPES, TEN MOST IMPORTANT STATES, PRODUCTION,* 1937–39, IN SHORT TONS

United States Department of Agriculture

State	1937	1938	1939	Average
New York	89,100	55,600	75,600	73,434
Michigan	67,200	16,900	58,100	47,400
Ohio	37,800	9,800	42,800	30,134
Pennsylvania	26,000	15,700	23,200	21,634
Missouri	12,300	6,200	12,500	10,334
Arkansas	12,800	4,800	8,200	8,600
Illinois	8,600	6,300	8,800	7,900
North Carolina	8,100	6,600	7,500	7,400
Iowa	5,000	5,000	5,800	5,267
California	2,454,000	2,531,000	2,173,000	2,386,000
Wine varieties	641,000	641,000	548,000	610,000
Raisin varieties	1,407,000	1,443,000	1,255,000	1,035,000
Dried†	246,000	290,000	252,000	162,967
Not dried	419,000	283,000	247,000	316,667
Table varieties	416,000	447,000	370,000	411,000

*For some states, in certain years, production includes some quantities unharvested on account of market conditions.

† Dried basis: 1 ton of dried raisins equivalent to 4 tons of fresh grapes.

3. Selecting the soil.
4. Selecting varieties.
5. Determining time of planting.
6. Determining planting distances.
7. Securing the plants.
8. Setting the plants.
9. Managing the soil.
10. Training the vines.
11. Controlling insects and diseases.
12. Harvesting the crop.
13. Marketing the crop.
14. Protecting vines in winter.

1. Determining Size of the Enterprise. Many of the factors of importance here appear under the same heading in

(*Mo. Exp. Sta.*)

FIG. 196. A Missouri vineyard just prior to harvest.

Chapter III on "Establishing the Orchard." The acreage must be large enough to carry the investment in special equip-

FIG. 197. A western New York vineyard. The cover crop between the rows is buckwheat.

ment and to attract buyers. Such equipment need not be extensive, but a spray outfit, horse- or motor-operated, gang plows, and grape hoes will be needed. If the fruit enterprise is diversified, then some of this equipment may be used for other crops, reducing the overhead on the vineyard. Pickers are more easily secured for a sizable plantation, since longer employment is provided, than for a small one. The problem cannot be resolved into a definite number of acres, but this matter should receive very careful attention at the outset.

2. Selecting the Location. Select a location subject to the tempering influence of lake or river. The nature of such influence upon the growing season and the temperature range is well known. The grape seems especially responsive to it. Shallow streams or ponds have little effect, the depth of the water being an important consideration. The slope should be toward the water. Steep grades complicate cultural operations and increase the cost thereof.

Air drainage through and away from the vineyard is important in the control of many diseases and reduces the danger from late spring and early fall frosts.

In the southerly extensions of the industry the water influence is not such an important factor, but air drainage is a primary consideration.

3. Selecting the Soil. A good upland corn soil is well adapted to grapes. Light loams of all kinds, with good drainage, meet the requirements. Clay loams delay ripening of nearly all fruits and in them the drainage factor is of especial importance. Moderate fertility and moisture are necessary. Since the vineyard will, under the proper conditions, occupy the ground for years, it is not best to plant on naturally poor soil. On the whole, well-drained, gravelly loams, which are friable and easy to work, and which warm up early in the spring, make excellent soils for the grape. On such soils, evenness of ripening, good yields, and grapes of good size, color, flavor, and high sugar content may be expected.

The growing of a tilled crop during the year previous to planting is sound practice, since it tends to eliminate grass and puts the soil in good condition for planting.

4. Selecting Varieties. Select varieties of established reputation and proved adaptability to the region. In a market grape, growers look for wide soil adaptation, hardiness of wood, heavy yields, evenness of ripening, freedom from cracking of berries, attractiveness of appearance, ability to stand handling and shipment, freedom from shelling after picking, and good quality. In all but the last two factors, *Concord* takes high rank. It does shell after picking, but its quality, though not superior, is good enough, when the fruit is well ripened, to suffice. It handles and ships fairly well, though leaving something to be desired in this regard.

At the present time, build a list of varieties around Concord as the major sort, lengthening the season on both ends with other kinds as the growing conditions and outlet warrant.

Sheridan, originated by the New York Agricultural Experiment Station at Geneva, should be watched as a possible successor to Concord. It is about ten days later than Concord.

To precede Concord by about three weeks *Fredonia* is a good-quality black grape. It is vigorous, hardy, and productive with large clusters of medium-sized fruit. *Worden* is a black variety of high quality which ripens earlier than Concord. The berries are large but very tender and may ripen unevenly. Worden does not ship well but is excellent for local trade.

Niagara is the leading white variety. Although it is not so hardy as Concord, it may be just as vigorous and productive if it is grown under suitable conditions. It is more subject to disease. If properly ripened, Niagara is of excellent flavor.

Portland deserves attention as an early white grape. The bunches are large, and the vines hardy and productive.

Ontario is a golden yellow grape of high quality. The clusters are of medium size and very attractive.

Catawba is the standard red grape. It must be grown where the season is long enough to mature it properly. The foliage and fruit are susceptible to disease. Catawba will keep well. It makes a high-grade, light-colored wine.

Keuka is a red grape which ripens one week earlier than Catawba. It has a very good flavor and is a new variety of the European type. *Urbana*, red, is a good grape but a little later than Catawba and for that reason its planting districts are limited. *Delaware* is a very high-quality American table grape. The berries are very small. The plants grow slowly and should be planted closely. The high quality of this grape makes it useful for wine making and champagne blending. It grows fairly well if planted in rich soil.

Recently the introduction of European types and seedless kinds has changed the list of grape varieties for home vineyards and roadside markets. It takes many years, however, to revise the list of standard commercial varieties of any fruit which has as long a life as the American grape.

Consult the local experiment station before making a final selection of varieties either for market or home use.

5. Determining Time of Planting. Plant in the spring in the northern regions of commercial production. Elsewhere, plant in the fall or spring at the grower's option. It is important, as in all fruits, that the plants should be in the ground early while spring rains are still abundant.

6. Determining Planting Distances. Strong growing varierties on fertile soil need 10 feet of space both in and between the rows. This is not too much for Concord grown under favorable conditions. Set less thrifty varieties 8 feet apart in the rows, or some, as Delaware, even closer, but the space between rows should always permit free use of implements, including tractors. Even though carefully trained, the trunks of some of the vines, when mature, will arch in such manner as to lessen materially the available tillage space. At 10 feet each way 435 plants per acre will be required.

7. Securing the Plants. Grapes may be grown from cuttings, or from layers, as described in Chapter VII, "Propagation." The commercial grower, however, will usually prefer to secure his plants from the nurseryman who is a specialist, and who probably will produce better plants on the average than the grower. Use well-rooted one-year plants (Fig. 198).

On arrival of the plants from a nursery open the bundles and heel them in carefully until ready to set in the field.

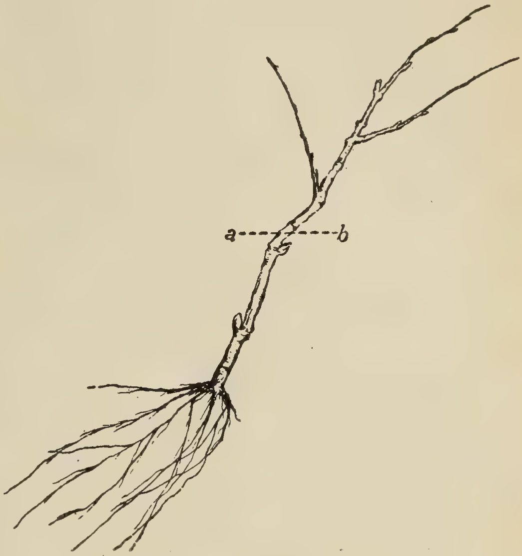


Fig. 198. A good one-year vine. It should be pruned at *a-b* when planted.

8. Setting the Plants. Grapes should be set on tilled land, preferably that which has grown a cultivated crop the year previous to planting so that grass and weed growth has been destroyed in large measure. The land should be plowed and worked deeply so that hand labor in setting may be reduced to a minimum.

Procedure:

(*a*) Determining arrangement of the rows.
(*b*) Marking out rows.
(*c*) Setting the plants.

(*a*) *Determining Arrangement of the Rows.* Run the rows north and south if the dimensions of the field permit, to distribute the sunshine to both sides. If prevailing winds are strong, it is best to avoid running the rows at right angles to them, since much damage may be done to young shoots and fruit-bearing canes. However, greater damage usually comes from sharp squalls in connection with sudden storms than from steady breezes from a certain quarter.

If the location is steep and uneven, then the contour of the ground must be followed, but it is a serious question whether vineyards in the future should be planted on such fields, where the cost of every operation is greatly increased.

Many persons get their impressions of American grape growing, or viticulture, from pictures of the steep, vineclad slopes of the River Rhine. We are dealing here, however, with an extensive method of management, where labor costs are at a maximum, and the efficient use of machines is indispensable to a high measure of success.

In large plantings, provide driveways at convenient intervals across the field so that it is not necessary to go to the end of the rows to take out a load of fruit or to refill the spray tank. Headlands adequate for turning beyond the end posts are necessary.

(*b*) *Marking out Rows.* Turn right angles where necessary as indicated in the chapter, "Establishing the Orchard." Plow out the rows the long way of the field, setting enough stakes for the driver to use in sighting. The cross-rows may also be plowed, or located with a marker, or a light stick of the proper length may be carried from vine to vine as planting progresses. Reasonably straight cross-rows are desirable because they make possible cultivation both ways until the trellis is up. They will not be obtained on large areas unless marked out in advance of planting.

Crooked rows with vines out of place are a great nuisance in all tillage operations. Exposed vines are sure to be torn out or seriously injured by tillage implements. It is a continual game of hide and seek to avoid them. The wires of the trellis cannot be properly tightened, and the net loss of efficiency is considerable.

(*c*) *Setting the Plants.* Plant in gangs of two persons. One of these may be a boy or girl, since the work is not heavy if the rows have been plowed out. Carry the plants with the roots immersed in a pail of water or covered with a blanket. The hole may be quickly finished with a shovel by one member of the gang. The other member prunes the top to two or three buds and cuts back straggling roots. He then shakes the vine to spread the root system, presses it against the bottom of the hole, and packs the soil as it is shoveled in. The whole operation may be done more quickly than it can be described.

If the rows have not been plowed, extra men must go ahead to dig the holes or the work must be done as the vines are set.

The more careful the preparation of the field by plowing and harrowing, the more rapidly will the planting operation go forward. The best cultivation that may be given any crop the first year is that which occurs, if the grower is wise, before the crop goes into the ground.

9. Managing the Soil. Thorough cultivation is the password to success after planting. The grape comes into leaf late in the spring. It develops a tremendous foliage in a very short period, in addition to producing the crop. The need of favorable growth conditions is apparent. Grape roots are relatively close to the surface. Moisture must be abundant and the soil in excellent physical condition. All this calls for frequent and thorough tillage.

Procedure:

(*a*) Cultivating the soil.
(*b*) Growing intercrops.
(*c*) Growing cover crops.
(*d*) Fertilizing the vines.

(*a*) *Cultivating the Soil.* In early spring, before the buds have started, plow away from the rows in order that opportunity may be given to clean the ground thoroughly beneath the vines. The three-gang vineyard plow (Fig. 199) meets the requirements. It should be run no deeper than is necessary to turn the furrow—from 3 to 4 inches. For the first two or three years, deeper plowing is permissible in an endeavor to force the vines to root more deeply, though how much is accomplished in this direction is debatable. On light soils free from stones, the disk harrow may be substituted for the gang plow, but the plow meets with greater favor for most conditions.

After plowing, cultivate thoroughly with the harrow. Finish next to the vines with the grape hoe, and even with the hand hoe. The grape or horse hoe, or "take out" (Fig. 200), is a tool which means much in the saving of time and in finishing cultivation well about the vines. Once the art of its manipulation is mastered, it becomes the grower's best friend.

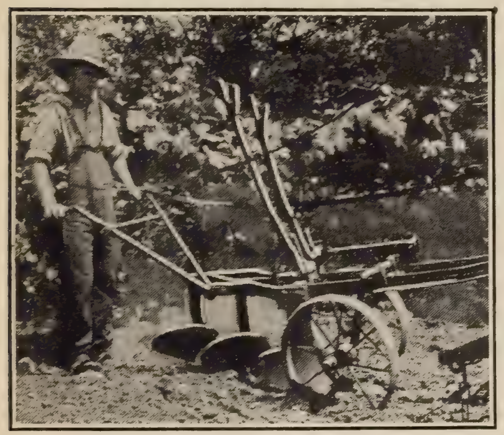


Fig. 199. The vineyard gang plow is a very useful implement in grape growing. It should usually turn a furrow from 3 to 4 inches deep. Tractor gangs may be used on level ground.

Through the summer, work the soil gradually back toward the rows until the ground is level, using the spring-tooth and disk harrows set at shallow depth. If drainage is a factor, ridge the soil in the rows slightly at the last cultivation, using the attachment on the grape hoe to do this. As part of the final cultivation, the gang plow may again be used, this time throwing the soil toward the vines. In the young vineyard, cultivation may continue to August 15 or even later, but in the bearing vineyard tillage should cease from July 15 to 30, depending on the season and the crop. If the season is dry and the crop large, prolong cultivation to conserve the moisture. If moisture is abundant, discontinue cultivation to induce maturing of wood and fruit. It is essential that the wood shall go into winter well ripened; otherwise injury from freezing, with its unfavorable effect on crop prospects of the following year, is likely to occur.

(*b*) *Growing Intercrops.* Intercrops that require cultivation have a place in the vineyard during the first season. Select the one that fits best in the rotation and the system of farm management. It may well be field or sweet corn, beans, or some of the garden crops. Perhaps the best feature of the intercrop is that it makes probable more thorough cultivation of the vineyard than would otherwise be given. It should be recognized, however, that, from the standpoint of the vineyard itself, its cultivation through the cultivation of intercrops is an expensive way to get the job done. The income from the crop may not make up the difference in cost, to say nothing of giving a profit. The grower must decide which, for his conditions, is the better way.

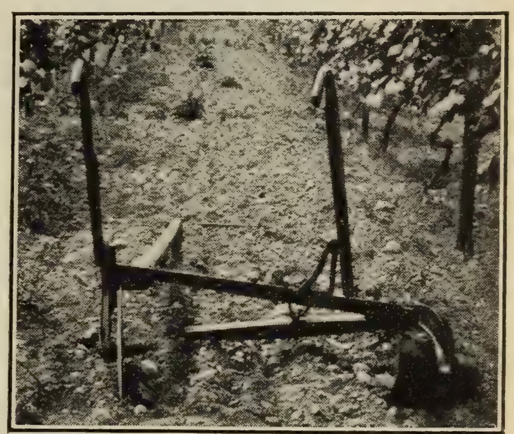


Fig. 200. The grape hoe may be thrown toward or away from the vines quickly by manipulating the left handle. The shovel on the right may be reversed to throw the soil toward the vines. A spring-tooth attachment between the disk and the shovel is also available.

(*c*) *Growing Cover Crops.* Many vineyards are productive thirty or forty years from planting, and a life in excess of sixty years is not uncommon. This is a long time for the effects of intensive tillage to accumulate. One of these effects is the gradual exhaustion of the supply of organic matter. The soil "burns out," creating an unfavorable medium for crop production. This occurs eventually even with the best of soils, unless remedial measures are employed.

Manure may be applied where available, as indicated under fertilizers. Cover crops can be grown to help keep the soil loose and friable.

Fig. 201. The tractor and spring-tooth harrow make a good combination for tillage where the land is not too steep for the tractor.

(*Caterpillar Tractor Co.*)

Fig. 202. A tractor pulling a Killefer disk and leveling harrow in a California vineyard.

Conditions differ from those in orchards. For the vineyard the cover crop must grow quickly and preferably lodge or fall of its own weight before picking time, and it must not grow high enough to reduce seriously air movement about the fruit. Such a reduction encourages the development of fungus diseases and delays the maturing of the fruit.

A crop that lives over winter has some obvious advantages, but it must be one that can be turned under or worked in by shallow plowing and cultivation. One difficulty with rye is that it grows so rapidly in the spring that it may get out of bounds in this regard.

Soy beans, sown in middle July, have given excellent results in some New York vineyards. Buckwheat (Fig. 197), oats, rye, winter vetch, and millet are worth consideration. The clovers often will not catch in a dry season, the time is too short for a good stand, and the seed cost is high. A mixture of 1 bushel of rye and 20 pounds of vetch is often used and is satisfactory if plowed under early in the spring.

Broadcasting by hand or with a cyclone seeder insures complete coverage, but if the cover crop is one that lives over winter, it will be easier to turn it under at the proper time if seeded with a drill, keeping a foot or so away from the rows. If the crop does not go down of its own accord at harvest, drag or roll it down while wet to get it out of the way of the pickers.

An auxiliary effect of the cover crop that is often important is its influence in hastening maturity of vine and fruit through cutting down on the supply of moisture available to the vines. It also reduces erosion of the soil on slopes and uneven ground.

(*d*) *Fertilizing the Vines.* Fertilizers should be applied when sufficient vine growth and fruit production are not secured without them. In many of the commercial grape regions of the northeastern United States, satisfactory vine growth and production are secured, especially on the heavier and more fertile soils, without the addition of commercial fertilizers or manure. On the lighter, sandy, or gravelly soils, profitable returns will usually be secured, however, from the addition of either or both of these materials.

Factors such as good air drainage (freedom from frosts), soil drainage, proper pruning, thorough cultivation, the addition of organic matter, the control of insects and diseases, soil temperature and aeration, and winter injury exert a marked influence upon vine growth and fruit production. If proper attention has been given to all these factors, and the vineyard still makes an unsatisfactory growth with resultant low fruit production, fertilizers should be added.

In many vineyards nitrogen seems to be the fertilizing element most often needed. A review of experiment station recommendations and of experimental evidence shows that in the Northern states, if satisfactory growth and yields are not secured, although good vineyard management is practiced, then applications of nitrogenous fertilizers will usually be beneficial.

In such cases, annual applications of 5 to 10 tons of barnyard manure per acre should produce good results. If manure is not available, about 300 pounds per acre of nitrate of soda should also produce good results, but under conditions where vine growth is very weak it will often pay to apply 400 to 500 pounds of nitrate of soda per acre.

In the lighter soils of the South and in some of the northern vineyards, a profitable response is apparently secured by applying phosphoric acid and potash as well as nitrogen. Under such conditions applications of 800 to 1000 pounds of acid phosphate and 200 to 300 pounds of muriate of potash in addition to the nitrogen should be made. It is possible, however, that too frequent and too liberal applications of manure and nitrogenous fertilizers might cause an excessive wood growth and diminish the crop. The amount of growth and yields being secured should thus be considered in deciding on the fertilizer program.

When manure is to be applied to the vineyard, it should be spread evenly between the rows before plowing or disking in the spring. Commercial fertilizer should be applied two or three weeks before growth starts. Available nutrients will then be present to stimulate early growth and to help cause a better set of fruit than would be obtained otherwise.

10. Training the Vines. All knowledge of grape culture points to the absolute necessity from the commercial standpoint of some system of pruning and training adopted early in the life of the vine and followed regularly year by year. Otherwise the vines grow out of bounds and the clusters of fruit are small and scraggly.

Procedure:

(*a*) Establishing the trellis.
(*b*) Determining the system of training.
(*c*) Pruning and training the vines.

(*a*) *Establishing the Trellis.* Where good growth of vines has occurred, the trellis should be in place ready to support the vines at the beginning of the second season, otherwise not later than the beginning of the third season.

A post between every two vines, or about 20 feet apart, is good practice. The alternate post may be lighter than its neighbor, but should still be strong and rigid. All posts should be from 7½ to 8½ feet long, preferably sharpened so that they may be driven into the ground each spring if necessary, and of wood naturally durable, or treated to make it so.

It is good practice to treat all posts, since their period of service will be materially increased. Replacement costs on the trellis form a considerable item and should be reduced to a minimum by adopting the most improved practices. Do not set green posts, or those with the bark on. Cedar, locust, oak, and other good post woods of local reputation represent proper choices.

Make certain that the posts align well with the vines in the row, as a post out of line is a sore thumb throughout its stay in the vineyard. For the same reason crooked posts are not desirable.

In regions where snowfall and drifting are not a factor, galvanized-steel posts have given satisfaction. They will not, however, withstand strong side pressures, breaking off at the ground.

The wire trellis is the arbor of commerce. Place strong posts, firmly anchored and braced, at the ends of the rows (Fig. 203). At appropriate distances, insert posts in the row to support the wires, attached to the posts by staples extra long. These staples are not driven into the wood full length, as in building a fence, but are left so that the wires may play freely through them. This permits the wires to be tightened from the ends of the row, through the use of patent fasteners or stretchers which may be turned up as the wires become slack, or through the manipulation of hammer and pliers around the end posts.

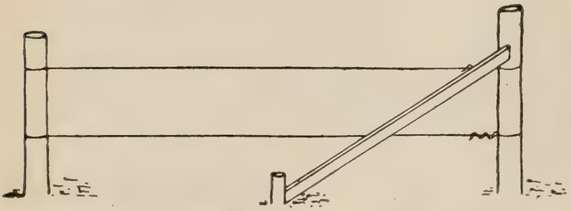


FIG. 203. This is the common method of bracing the end posts of the trellis.

Number 10 wire, well galvanized, running about 2000 feet per hundred pounds, is easily handled and makes a strong trellis. Some growers prefer the heavier No. 9 wire, and others No. 11.

Use two wires per row, running the lower from 30 to 36 inches from the ground, depending on the variety and location. It should be high enough to permit free air circulation beneath the canes which will be attached to it.

The second or top wire should be about 24 inches above the first wire. Put the wires on the sides of the posts toward the prevailing winds, so that pressure may be against the posts rather than the wires. The strain on the trellis under a heavy load of foliage and fruit is very great. For the same reason bring the vines up and train them on the windward side of the trellis.

(*b*) *Determining the System of Training.* With the trellis in place, vine training to a definite form begins. Although many systems have given good results, from the standpoint of simplicity, economy, and results, the single-trunk, four-cane *Kniffin* system takes precedence, and is the only system described in detail here. Essentially it consists of a permanent trunk extending to the top wire. At each wire a cane, renewed every year, is laid down in each direction. This is the fruiting wood or cane. There are then two arms or canes on each wire or four for the vine as a whole. To these arms coming directly from the trunk, or near it, are added short spurs or canes at each wire from which the canes may be renewed the succeeding year.

(*U. S. D. A.*)

FIG. 204. A vine pruned after one year's growth in the vineyard.

(*c*) *Pruning and Training the Vines.* Cut back the vine to two buds on a single stub at planting (Fig. 198). Repeat the operation at the beginning of the second season. The top is thus no longer at the outset of the second year than it was the year before. The plant does have a more extensive root system and will grow a much larger top during the second season than the first.

Select, early in the second season, the strongest shoot that develops from the buds on the stub and rub off the others, so that the growth may be directed into a single shoot. The vines may be staked during the season to get them off the ground and out of the way of cultivation, or the lower wire of the trellis may be put up, tying the vines loosely to it. Frequently, however, they are allowed to run on the ground during the second season.

The third spring from planting tie the single cane to the top wire firmly so that it is taut, thus preventing the crooks and arches in the trunk that later prove so troublesome in tillage operations (Fig. 205). Cut off the cane just above the top wire, at the same time tying it loosely to the lower wire for the sake of support.

(*Md. Exp. Sta.*)

Fig. 205. A vine pruned and tied after two years in the vineyard.

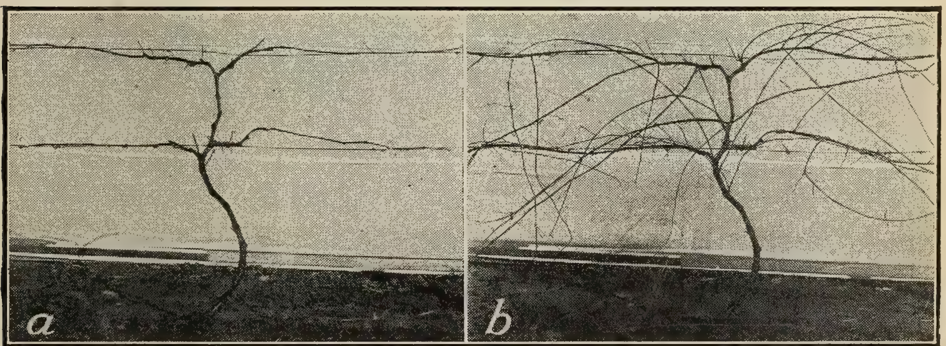
Leave nothing but this single upright cane, unless the vine is exceptionally strong, when short side arms may be left each way along the lower wire. From these some fruit may be borne the third season. Buds will be present along the entire length of the trunk. As shoots develop from them near the base or suckers spring from the ground level, rub them off, repeating the operation two or three times during the season. Side shoots will appear both to the right and left of the trunk. These constitute the fruiting wood for the coming season.

Strictly speaking, the fruit is borne on shoots that develop in the spring from buds on wood that was formed the previous season (Fig. 206). If all new wood remains, the clusters of fruit have the characteristic loose and scraggly appearance of those on unpruned grape arbors or wild vines. From the commercial standpoint the vine "overbears." To prevent this, leave at pruning time only a fraction of the fruiting wood. The part that is permitted to remain is naturally that adjacent to the wires where it may be tied.

Select, therefore, the fourth spring, a single cane each way from the trunk, on each wire, making four canes in all (Fig. 207). Leave canes at the top wire at the "head" of the vine longer than on the lower wire because growth is more active at the upper extremity. Canes of medium length for the vine being pruned and those above the average in diameter, but not the largest or overgrown, with buds well spaced, are preferable. For the Concord, medium-length canes of pencil size, or about ¼ inch in diameter and with not less than 6 inches between the fifth and sixth buds, have thus far given very good results in experimental trials.

(*N. J. Exp. Sta.*)

FIG. 206. A grape shoot that has pushed out from the bud in the spring. The blossoms are at *a*.



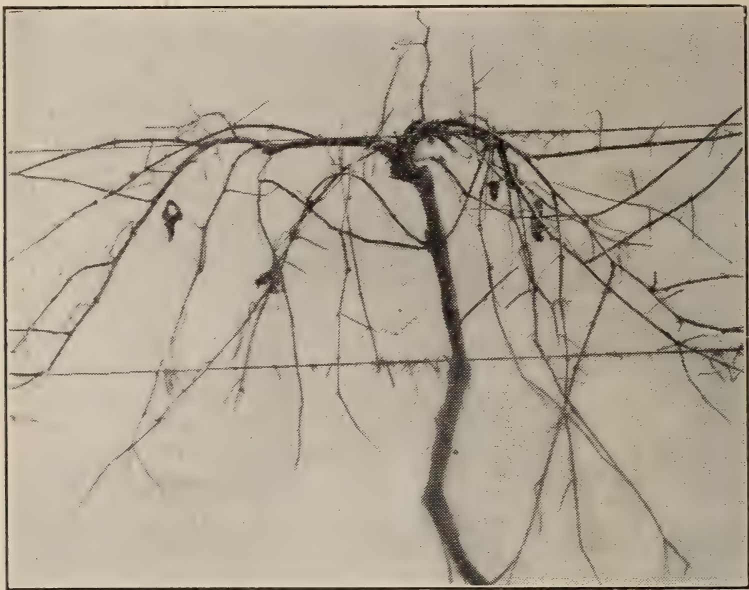
(*Md. Exp. Sta.*)

FIG. 207. (a) A bearing vine pruned and trained according to the single trunk, four-arm Kniffin system. (*b*) The same vine before pruning.

These specifications would, of course, vary with the vigor of the variety.

Forty buds are often prescribed as the proper number to be left. This may do for a general rule, but the intelligent vineyardist will take into account the variety and the vigor evidenced by the vine in question. Vines lacking in vigor require heavy pruning to reduce the fruiting load; strong vines will carry a proportionately larger amount of fruiting wood.

The upper arms will each carry two buds more than the lower arms. In addition to the four arms, leave short spurs of one or two buds at or near the junction point of each arm



(*Cornell Exp. Station*)

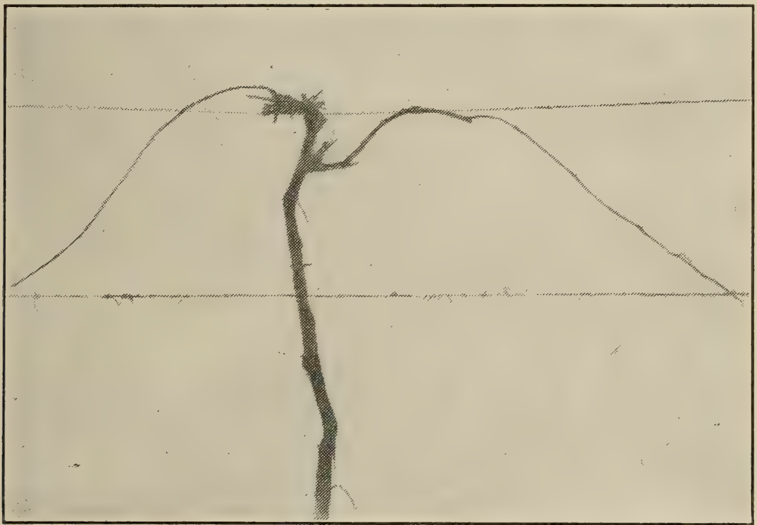
FIG. 208. The two-arm Kniffin system before pruning.

with the trunk. From these spurs renewal arms, or canes, will be taken the following year, for it must be kept in mind that these arms must be replaced each season with wood of the previous year's growth.

After pruning, tie the canes along each wire, using soft twine or willows. Tie just back of the end bud and also back near the trunk, so that the cane may not pull loose. The fruit when borne will hang below the wires, easily accessible for picking, with good aeration, yet protected from sun and frost.

Shoots that develop during the growing season are permitted to droop or hang at will, excepting that sprouts or suckers near the base of the vines should be removed two or three times a season.

Several other systems of training are used almost exclusively in certain sections. The two-arm Kniffen is similar to the four-arm Kniffen, the difference being that only the upper laterals are left to produce fruit. The umbrella Kniffen system is a further modification of the two-arm Kniffen. In this

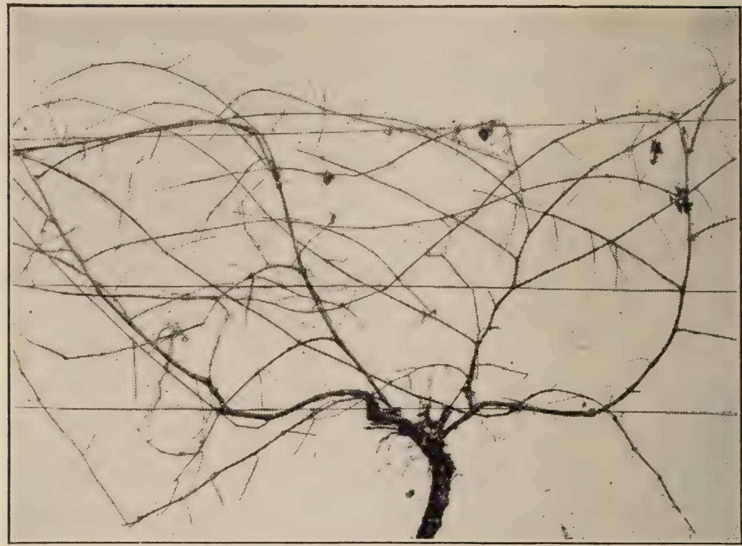


(*Cornell Exp. Station*)

FIG. 209. The two-arm Kniffin system after pruning. The laterals are tied to the lower wire.

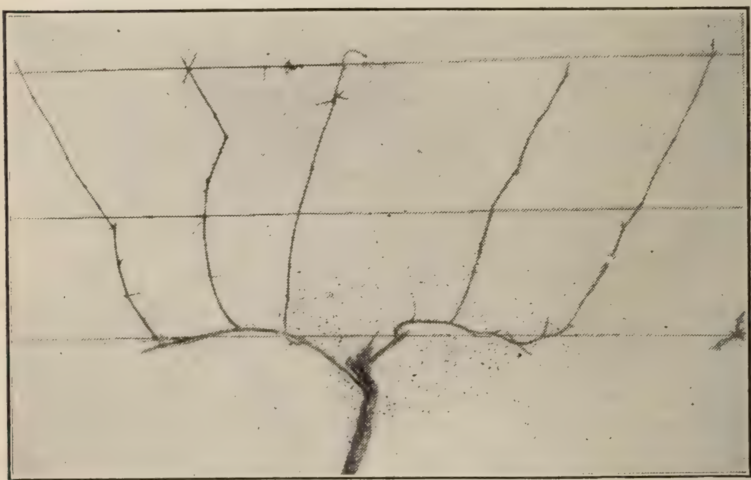
case the ends of the laterals are tied to the lower wire (Figs. 208, 209). The Chautauqua arm system requires three wires on the trellis. In this system the upright canes are one-year-old wood (Figs. 210, 211). The Keuka high renewal system of training requires three wires and more tying (Figs. 212, 213). In this system the side arms are one-year-old wood and the uprights are new growth.

Modifications of any of these systems may be used to advantage in some places. In fact, grape vines may easily be trained to cover any trellis according to the grower's wish.



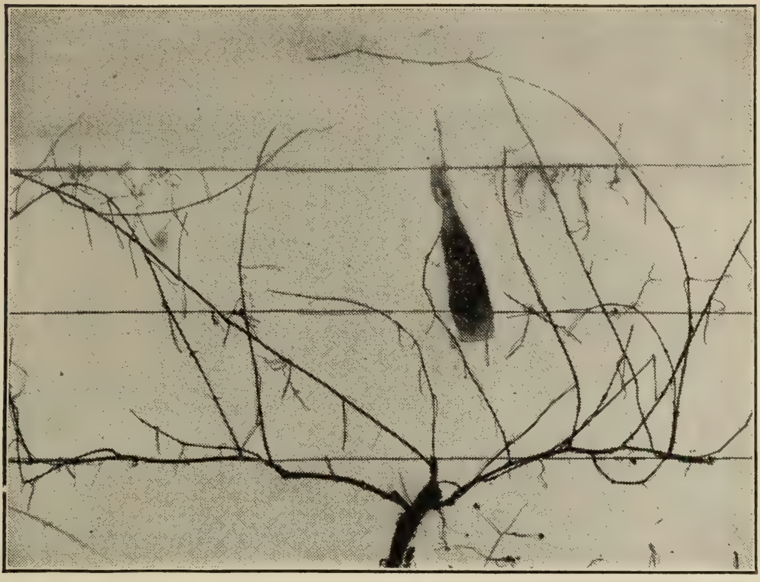
(*Cornell Exp. Station*)

Fig. 210. The Chautauqua system before pruning.



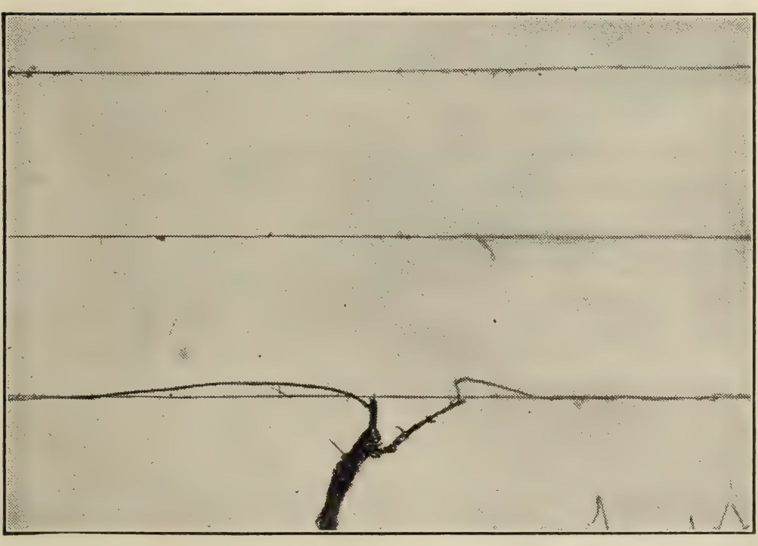
(*Cornell Exp. Station*)

Fig. 211. The Chautauqua system after pruning.



(*Cornell Exp. Station*)

Fig. 212. The high renewal system before pruning.



(*Cornell Exp. Station*)

Fig. 213. The high renewal system after pruning.

In pruning, work on the right-hand side of one row and on the left-hand side of the adjacent row in such a manner that the prunings from the two rows may be thrown into the space between them. In removing the pruned canes from the trellis, give a quick pull along the wire rather than at right angles to it, so as not to tear the wires loose and also because less effort is required to remove them in this manner.

In removing the prunings from the vineyard, a 12- or 14-foot pole is useful. Hitch a single horse to the larger end of the pole with the hitch about 2 feet from the end, using a chain long enough so that the horse walks well ahead of the pole. The driver may hold the light end of the pole in his hand, varying the height as necessary. The prunings will accumulate about the larger end as it is pulled along by the horse. Some growers prefer to load the prunings on to a wagon in the adjacent row, with forks; others haul them out with a spring-tooth harrow.

Results of Recent Pruning Tests. Frequently the first commercial crop may be secured one year sooner by following the results of recent investigational work. When free-growing varieties, such as Concord, are planted on good grape soils, and in addition are manured and fertilized with a quickly available nitrogen fertilizer the first season, sufficient vine growth is usually made so that one of the canes can be tied to the top wire of the trellis at the beginning of the second season's growth. In such cases, it is neither wise nor profitable to cut back the cane to two buds at the beginning of the second season as described under the preceding general recommendations. A little fruit will be produced along this trunk in the second year, and many new shoots will be formed, so that the complete four-arm Kniffin system may be established at the beginning of the third season's growth. As a result, a full commercial crop will be secured one year sooner than is customary. When this method is followed, the trellis should be erected and the vines tied to it at the beginning of the second year's growth. This early fruiting does not appear to dwarf the vine or reduce future crops, if good soil fertility is maintained.

If the cane is not long enough to tie to the top wire, at the beginning of the second season, it may be tied to the lower wire. At the beginning of the third season, the trunk may then be continued with a new cane to the top wire and two canes may be tied along the lower wire. A fair crop will result the third season.

Although unusual, it is also possible, when following the customary training methods previously described, to have a number of vigorous laterals produced on the long cane which results from cutting back to two buds after the second year's growth. When such conditions of growth do occur, these laterals may be used during the third year for producing a partial crop.

Cane Renewal. When the main trunk becomes devitalized, not producing canes of good vigor and location, its renewal is desirable. Select a sprout or sucker from the base of the trunk and develop a new trunk gradually, pruning the old vine more severely than usual in the meantime. After the third year, the old cane may be removed, without in the meantime taking the vine completely out of production.

Time of Pruning. Present information indicates that early spring is the best time for grape pruning. This means February or early March in most regions. Fall-pruned vines may show considerable freezing injury in the spring with consequent reduction of the crop. Grape wood is too brittle to work with when full of frost. Excessive bleeding results from pruning too long deferred. The effect of this bleeding has not been fully determined, but it seems best to avoid it until more definite information is available.

One exception to the foregoing statement may be desirable. In regions subject to severe, late frosts, it may pay to delay pruning until late spring, even though some bleeding may occur. By delaying the cutting back of the canes, those buds which will be left eventually do not force out into growth as early as if the canes had been headed back at the usual time. The buds at the ends of the canes, which will be removed anyway, are then the ones which will grow early and no harm to the crop will result if these are frosted.

Hand shears of a good grade of steel are the most satisfactory tools for pruning. These are shown among orchard pruning tools, page 231. More powerful shears, or a saw, will be needed to cut out large stubs and old vines.

11. Controlling Insects and Diseases. Since grape foliage is relatively close to the ground, and since many of the organisms to be controlled work on the under side of the leaves, movable or flexible booms equipped with nozzles spraying upward from below as well as downward from above are desirable. Sprayers of the traction type are sometimes used, but gasoline engine outfits with long leads of hose, or "trailers," the men spraying from the ground, are preferable.

Liquid lime-sulfur has not been satisfactory and is not used in the vineyard. Bordeaux mixture is the standard fungicide. The ordinary orchard insecticides may be used in the vineyard.

Among insects, the grape root worm, the grapeberry moth, the leaf hopper, and the grapevine flea beetle are serious pests. The rose chafer is occasionally very destructive in sandy areas or where such areas are nearby.

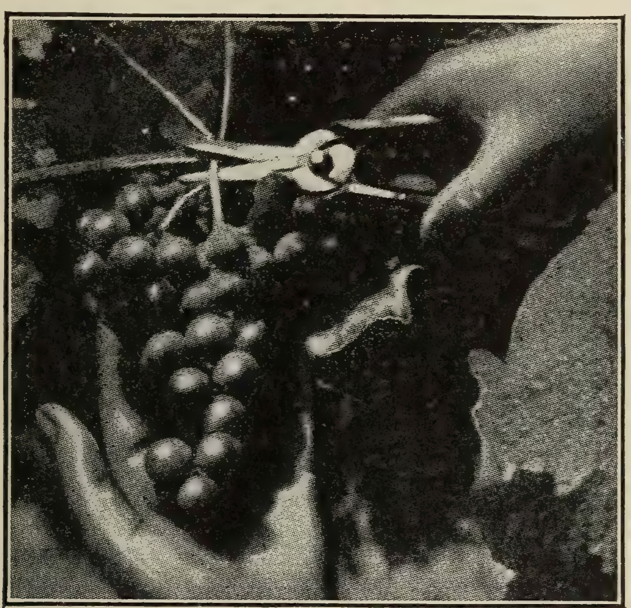
Among diseases, black rot is very destructive in humid sections, in wet years, and on some varieties. Downy mildew is often serious. Dead arm disease is serious in some sections.

Follow the control program outlined by the local experiment station. A full discussion of materials, machinery, and methods of application will be found in the chapter entitled "Controlling Insects and Diseases."

12. Harvesting the Crop. Pick the fruit when full color has been reached and when the natural flavor has developed. Unripe grapes are an abomination to the consumer and sure parents of a declining demand. Only experience will indicate the proper stage and appearance for picking. The wood assumes a characteristic red or chocolate appearance. The bloom on the clusters becomes apparent. Preserve the bloom carefully by a minimum of handling, as it is evidence of skill and consideration, a bond between grower and consumer.

For distant markets and shipments long in transit, pick earlier than for immediate local consumption where the full quality should be permitted to develop. Some varieties, as Moore Early, tend to crack if left on the vines too long, especially if rains have been abundant during the ripening period.

Pointed spring scissors, known as picking shears, serve best. Clip the stem closely so that the stub may not extend to puncture adjacent clusters (Fig. 214). Remove all defective berries, taking care not to puncture the skin of the berries that remain.



(*Mo. Exp. Sta.*)

Fig. 214. This illustrates a good method of handling the cluster when picking, holding the fruit gently in the open hand and clipping the stem close to the shoulder.

If the fruit is to be repacked at the packing house, the trimming of the clusters may be done at that time.

The fruit may be picked into trays or lug boxes holding from 20 to 30 pounds (Fig. 215). Place them on light, movable wooden stands, a little less than waist high, so that they may be filled and carried easily. Pick when possible from the windward side of the vines, since the foliage will be less dense, and the clusters more evident than on the off side of the trellis.

If supplying a local trade, nearby stores or stands where the fruit will be sold by the pound, the grapes may well be trimmed and packed ready for market direct from the vines. Pack the clusters closely to prevent slack containers, with stems down and the clusters at an angle in the upper layer to improve the appearance of the pack.

Set the filled trays under the vines to protect them from the sun. Haul from the vineyard in narrow, short-turning wagons.

Fig. 215. The tray on the stand, ready for picking. Both tray and stand are carried from vine to vine.

The climax basket is the customary retail package. It holds 2, 4, or 12 quarts, with specifications prescribed by federal statute for interstate shipment. The 2- and 4-quart sizes are used most for table stock. Gift crates holding a number of baskets are in use in some sections. The baskets should be neatly stamped. Attractive labels on the covers may be desirable for some trades.

The baskets may be packed direct from the vines by experienced workers (Figs. 216, 217, 218, 219). There is an advantage in the one handling. However, payment by the basket for picking should not be made in this case, especially for table stock, as the temptation to fill the baskets loosely and without careful trimming is great.

Machines now available fasten handles and covers quickly.

Yields in commercial sections run from 2 to 4 tons per acre, 5 to 6 tons occasionally being reported. On the Pacific Coast, the yield of the Vinifera grape is much greater.

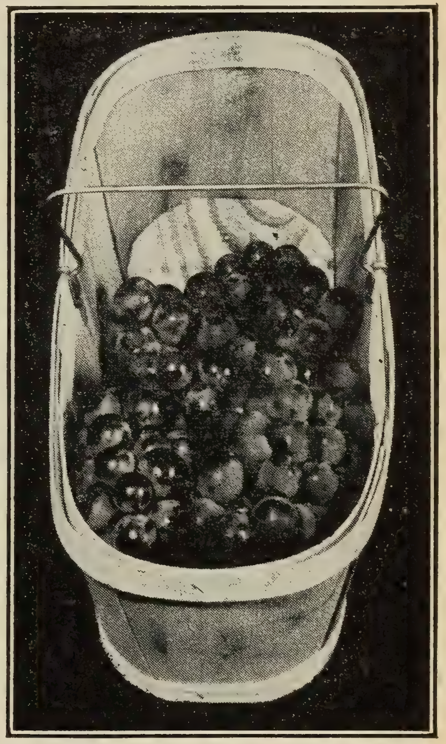
13. Marketing the Crop. Load baskets tightly in carlot or truck shipments. Failure to do so, taking up all slack space, results in serious losses (Figs. 221, 222). A car of loose baskets is a juice factory on wheels. Follow the loading diagrams and instructions provided by the railroad company.

Icing may be necessary for distant markets.

The grape-juice factory provides an outlet that has grown steadily in importance through the years. The juice factories desire only well-ripened fruit, chiefly Concord, with a high

(*U. S. D. A.*)

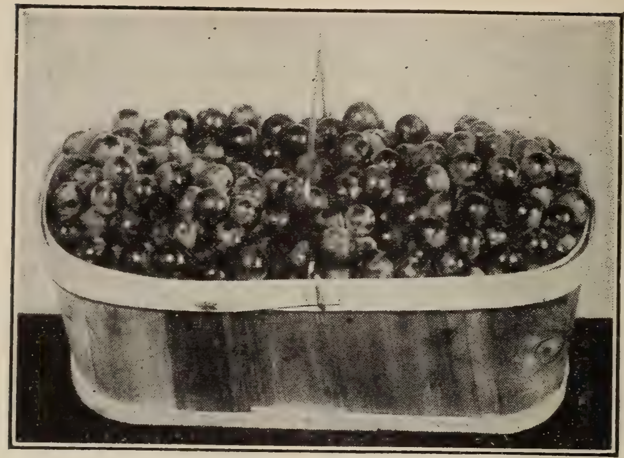
Fig. 216. Grapes are often packed in climax baskets as they are picked from the vines. This bench shows a tray below for the second-grade fruit.



(*U. S. D. A.*)

Fig. 217. Fill the lower end of the basket first, keeping the cut stem ends down and working the clusters gently together to give a compact and attractive pack.

sugar content, attributes that are desirable in any case and that the grower must provide if the market is to expand. These factories usually buy the fruit on a standard contract basis.



(*U. S. D. A.*)

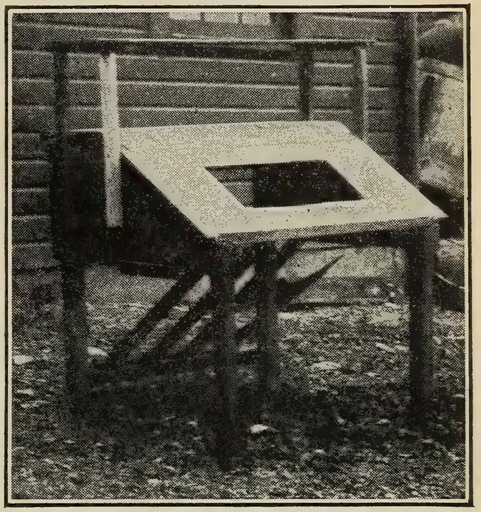
FIG. 218. A well-packed basket with a full, even surface, ready for the cover.

(*U. S. D. A.*)

FIG. 219. This is a good type of picking stand. The sloping position of the baskets facilitates packing. Several grades may be made.

Well protected by foliage, grapes will withstand considerable cold. Once frosted, however, they shell badly and lose their flavor.

Marketing processes for the grape are marked by the development of numerous cooperative associations in some sections. In Michigan, this development is particularly marked, with sales on an f.o.b. basis. A cooperative association in the Chautauqua and Erie grape belt handled 895 cars of table grapes and furnished nearly 10,000 tons to grape-juice factories in one season.



(*U. S. D. A.*)

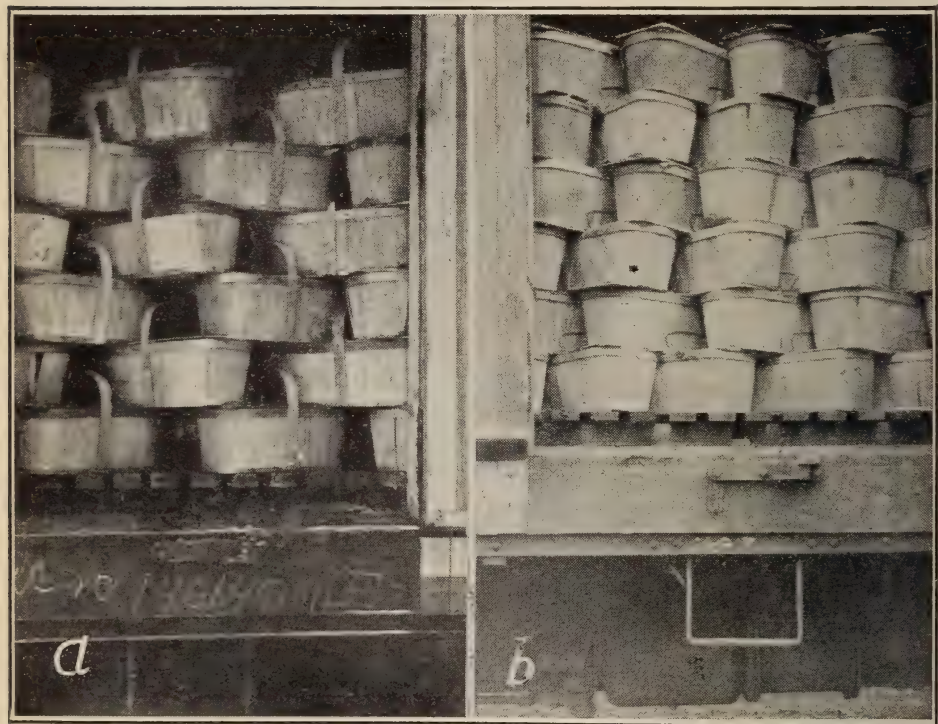
Fig. 220. A grape-packing table for one person when the fruit is not packed in the vineyard. The grapes from the field are placed on the table under the shelf. The packer pulls them forward, packing on the sloping surface. The tray, or lug, containing cull grapes is pushed through the hole and taken out at the rear. The packed baskets are placed on top of the shelf.

Fruit from the chief producing areas reaches the far South and west to the prairie states. The Pacific Northwest is supplied chiefly by the state of Washington, which has developed a considerable industry. There is need of better distributive measures to serve the whole area including the smaller towns, rather than a limited number of large centers.

Storage. Grapes will keep for some days in cool, dry, and well-ventilated common storage. If the weather is sharply cool, some varieties will keep for several weeks if in good condition. Usually the market improves considerably with the advent of such weather. Cold storage is desirable for longer periods. A temperature of 30° F. has given satisfactory results.

(*Merchants Despatch*)

Fig. 221. This illustrates the method of car loading, including turning the last row of baskets in diagonal or "worm" fashion to take up the space.



(*Merchants Despatch*)

Fig. 222. (*a*) A poor loading job at the car door. There is too much space between baskets, one basket handle is already broken. This car is almost certain to reach destination in bad condition. (*b*) These baskets have been well loaded at the car door.

14. Protecting Vines in Winter. Protect the vines in severe climates by releasing them from the trellis and allowing them to lie on the ground over winter. They may even be covered lightly with soil, if the cold is intense. This treatment applies to non-commercial regions where grapes are desired for home use, and especially to Vinifera grapes in northeastern United States.

GROWING MUSCADINE GRAPES

Muscadine (*rotundifolia*) grapes reach their highest perfection in the coastal plains region of the South. They are vigorous, long-lived, and remarkably free from insect and fungus troubles.

They are not adapted to marketing as dessert grapes at a distance, because the berries are inclined to ripen unevenly, the clusters are as a rule small, and the berries when ripe shell or drop from the clusters freely. Most varieties possess a strong musky taste. The fruit is adapted to home use, for wine making, and culinary purposes.

Propagation. Propagation may be from cuttings, when skillfully handled, but reproduction from layers is the common procedure. It may be more satisfactory to purchase the vines from a nursery. Two-year rooted layers are desirable.

Varieties. Thomas and Luola, black varieties, ripening in late August; Scuppernong, white, of the same season; Flowers and Hunt, black, ripening in late September, are the chief varieties.

Planting Distances. Most varieties should be planted in rows about 15 feet apart and 20 to 24 feet apart in the row. They thus require double the space of varieties of the Labrusca type.

Sterility. The varieties are for the most part self-sterile, though some self-fertile strains are now available; pollination takes place from the male vines, which produce staminate flowers, but no fruit. Male vines abound as a rule in the woods and hedge rows, but it is best to plant some rooted layers of staminate vines, which bloom heavily and at the same time as the pistillate vines, in the vineyard. A satisfactory arrangement is to have the third vine in every third row a male vine.

Training and Pruning. A three-wire trellis is commonly used, except when the vines are trained over arbors. The wires should be about 2 feet apart.

Prune the vines from late October to late November. Later pruning induces excessive bleeding. The method of pruning and training may be very similar to that for bunch grapes. Regular pruning each year should be the rule for the best results.

COMMUNITY STUDIES

1. Visit three growers—if possible, three that serve different types of markets. Prepare in detail a questionnaire before going, seeking the following information:

a. Types of soil—management previous to planting.
b. Varieties.
c. Cost of establishing vineyard up to four years of age, including erection of trellis.

Practices and costs on mature vineyard including:

d. Pruning and training (prune at least 3 vines per student).
e. Method of removing prunings from vineyard.
f. Cultivation and cover crops.
g. Fertilization of soil.
h. Insect and disease control program.
i. Picking.
j. Packing.
k. Yield.
l. Method of disposal of crop.
m. Is icing necessary—costs?

2. With this information make out a financial statement for a 20-acre Concord vineyard in a normal year in your section.

3. On the basis of your own studies, make definite recommendations for the improvement of the grape business.

a. In your section.
b. From a national standpoint.

4. Visit local grape-juice factories; learn the manufacturing process; observe the variety and quality of fruit desired. Study the local cooperative association and score it according to standards promulgated by the United States Department of Agriculture.

CHAPTER XIV

GROWING BUSH FRUITS

The bush fruits of chief commercial importance include the raspberry, the blackberry, and the dewberry—the **brambles,** as they are sometimes called—and the currant, gooseberry, and blueberry.

SECTION I. GROWING THE BRAMBLES

The red raspberry, black raspberry, purple raspberry, blackberry, and dewberry are the brambles of commercial importance for the country as a whole. To them, but not discussed in detail here, must be added the loganberry and the so-called Mammoth dewberry of the Pacific Coast, neither attaining importance east of the Rockies, owing apparently to inability to withstand climatic changes.

The *red raspberry* bears red fruit and possesses erect, rather slender canes, usually throwing suckers freely from the roots. Our varieties come from both European sorts and American wild plants, or crosses between them.

The *black raspberry,* commonly called "blackcap," produces black fruit, more seedy than the red. The canes droop or arch in late summer, and new plants are formed when the tips come in contact with the soil. All varieties have been developed from the wild sorts found commonly in eastern United States.

Yellow varieties appear from time to time, variants of the red or black. Some of these, as Golden Queen, are under cultivation.

FIG. 223. Raspberries—distribution of acreage in United States. Compare with blackberry and dewberry, Fig. 224.

FIG. 224. Blackberry and dewberry—distribution of acreage in United States. Compare with raspberries, Fig. 223.

The *purple* varieties are hybrids between the red and black, resembling the black raspberry in habit of growth and generally in method of propagation. They are largely used for canning purposes, and for pies, sauce, jams, etc.

The *blackberry* grows wild in most parts of the country. This has retarded its commercial development, but great improvement in varieties as to size, quality, length of season, etc., has now been accomplished.

The *dewberry* resembles the blackberry, but is prostrate in habit as a rule, the vines trailing on the ground. Some varieties, however, are semi-erect in habit. Its range is much the same as that of the blackberry.

None of the brambles, excepting perhaps the blackberry and dewberry, possesses the adaptability of the strawberry over wide areas. The red raspberry succeeds beyond the northern limit of hardiness of the others. The blackberry and dewberry succeed better in the South than other members of the group. The dewberry develops a deep root system and will thus withstand drought better than other members of the group.

Virus diseases, or mosaics, have become the chief limiting factors in raspberry culture. They largely determine the profitableness of the enterprise. Consult page 551 for further information.

Operations:

1. Determining the size of the enterprise.
2. Selecting the location and soil.
3. Determining the time of planting.
4. Securing the plants.
5. Selecting varieties.
6. Preparing the soil.
7. Determining the planting plan.
8. Setting the plants.
9. Managing the soil.
10. Pruning and training the plants.
11. Controlling diseases and insects.

12. Harvesting and marketing the crop.
13. Protecting the plants in winter.

1. Determining the Size of the Enterprise. Although the brambles are grown in large units for canning factories in some sections, the prevailing type of planting is a small acreage as a part of a diversified enterprise, with special attention paid to local and nearby markets. Up to its capacity, the local town or city is often the best market. Even the neighboring countryside will absorb large quantities, if the grower stays in the business year after year and supplies a good product. People come to look to him for their requirements, and farmers will often purchase for family use rather than seek to grow their own. The advent of good roads and the motor truck have greatly enlarged the local service area and the possible market for such growers.

The fruit is a soft and perishable product, ripening over a brief period. These facts must be kept in mind with regard to harvesting and marketing and will, of course, influence the size of the enterprise.

2. Selecting the Location and Soil. Select a site that provides good air drainage. This reduces danger from frosts at blossoming time and winter injury, and helps in disease control. The berries are lovers of cool temperatures; if a northern slope otherwise well adapted is available, it should be preferred. Locations where the snow drifts heavily may result in broken canes. On the other hand, a moderate amount of snow protects from freezing and is desirable.

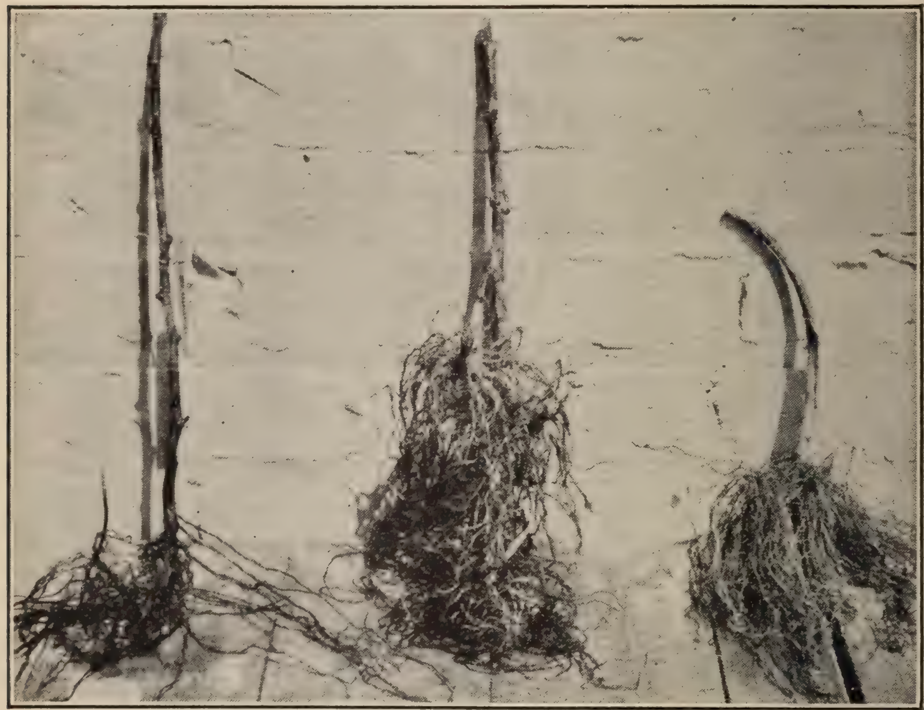
Plant on deep, rich loams. A light or medium type underlain with clay to hold moisture is probably best. The moisture requirement is a most important factor. It cannot be met by planting on wet or heavy land, but rather through the incorporation of organic matter, following the same general treatment outline for the strawberry and grape. So far as preference is exhibited, the dewberry accepts the light soils; the red and purple raspberries and the blackberry, the medium loams;

and the black raspberry, the heavier types. The terms are relative, and there are gradations and overlappings that make it difficult to set limits beyond the necessity of thorough drainage and friability, superior moisture-holding capacity, and abundant fertility. It is possible, however, to overdo the fertility factor, producing excessive growth that does not mature properly and is thus subject to more than the usual danger from winter killing.

3. Determining the Time of Planting. Plant in early spring. Fall planting for some members of the group will meet with success, especially in the southern reaches of the industry, but best results on the whole come from spring planting. This is especially true of the black raspberry. Protect fall-set plants during the first winter by mounding the soil about the canes.

4. Securing the Plants. The *red raspberry* throws suckers or young plants from the roots of the parent plants. They may be seen in early spring coming up everywhere along the rows. The most destructive diseases of this fruit at the present time are the virus diseases or mosaics. Unless it is known beyond question that the plantation is free from these diseases, no plants should be taken from it. It is much better to purchase certified stock from reliable nurserymen or growers who have followed rigidly the requirements for certification. One-year shoots are best, but new sprouts may be used. In the latter case, take up the plants with a few inches of the parent root attached. Do the work on a cloudy day and keep the plants out of the ground the shortest possible time.

The *black raspberry* roots from the tips of the parent canes which bend over in late summer until they make contact with the soil. The process is known as tip layering. If the soil is loose and moist, roots soon develop. If a large number of plants is desired, it is best to assist nature not only by providing a favorable soil medium, but also by throwing a little soil on the end of the cane, thus holding the tip in place until it becomes established. A late cultivation will usually accomplish this, but may be supplemented with hand work. Leave the tips attached to the parent plants until the following spring. Anthracnose, crown gall, and mosaics are usually the limiting factors in the life of the black raspberry. Remove the tip plants in early spring before they have become infected with anthracnose from the old canes.



(*U. S. D. A.*)

Fig. 225. Raspberry plants with good root systems desirable for planting. Ranere (red) at left; Columbian (purple) in center; Cumberland (black) at right.

The *purple raspberry* resembles the black raspberry, forming plants at the tip of the new canes. A few varieties, however, do not form tip plants, and must be propagated from suckers or root cuttings.

The *blackberry,* like the red raspberry, propagates from suckers, one-year plants being best, or, since some varieties form suckers but sparingly, new plants may be obtained from root cuttings. In the fall take strong roots from vigorous plants, cut in pieces 2 to 4 inches long, store in sand kept moist, but not wet, or in sawdust where the temperature is above freezing. Plant in early spring 4 to 8 inches apart in furrows, covering with 3 to 4 inches of soil. Keep thoroughly cultivated. The plants will usually be large enough the following spring for field planting.

The *dewberry* propagates either from tips or root cuttings. Most plants are secured from tips, but both methods give strong plants.

When buying plants from the nursery, order first-grade plants of the previous year's growth. Heel them in promptly on arrival, unless they are to be set at once.

5. Selecting Varieties.

Procedure:

(*a*) Consider local adaptations of varieties.
(*b*) Consider need for cross-pollination.

(*a*) *Consider Local Adaptations of Varieties.* Consult the local state experiment station about varieties. The judgment of successful growers in the region is valuable. There is great difference in adaptability and hardiness of varieties in various sections. There is much room for improvement in varieties, and doubtless better sorts for certain conditions will appear. Some of the experiment stations are directing much careful effort to this matter, and new developments should be watched closely. The lists given under "General Information" at the close of the chapter are guides only. The varieties mentioned should at least be considered in making selections. Check them against local experience and judgment.

(*b*) *Consider Need for Cross-Pollination.* Practically all the commercial varieties of raspberries are self-fruitful, and as a result can be planted in solid blocks. Very little experimental evidence is available on this question for red, purple, or black raspberries, but the fact that practically all the commercial varieties of these fruits are productive when planted in solid blocks, even at great distances from other varieties, is sufficient evidence that the pollination problem, if any, is a very minor one with them.

Practically all the common blackberry varieties are self-fruitful. There are a few hybrid varieties, however, such as *McDonald, Rathbun, Spaulding,* and *Wilson* which do not "set" well with their own pollen. Such varieties should not be

FIG. 226. Red raspberries grown in hedge rows without stakes or trellis. The canes have been clipped shorter than in Figs. 227 and 228.

planted by themselves, but with some other variety so that suitable pollen will be available for cross-pollination purposes. The *Mammoth* and *Cory Thornless* varieties have also been found to be more or less self-unfruitful under Oregon conditions, and it is suggested that provision should be made for cross-pollination if these varieties are grown.

Most of the commercial varieties of dewberries such as *Lucretia, Mayes* (Austin), and *Young* are self-fruitful, but certain varieties as *Premo*, *Chestnut*, *Grandee*, *Munroe*, and *San Jacinto* have been found to be self-unfruitful. In these varieties, provision must be made for cross-pollination or poor crops will result.

6. Preparing the Soil. Grow a tilled crop the year previous to planting. Prepare the soil deeply and thoroughly. An abundance of organic matter is desirable. Eliminate all grass and weeds, such as wild morning-glory and quackgrass, before planting, since, once the rows are established, it is almost impossible to combat such growths effectively. Follow the

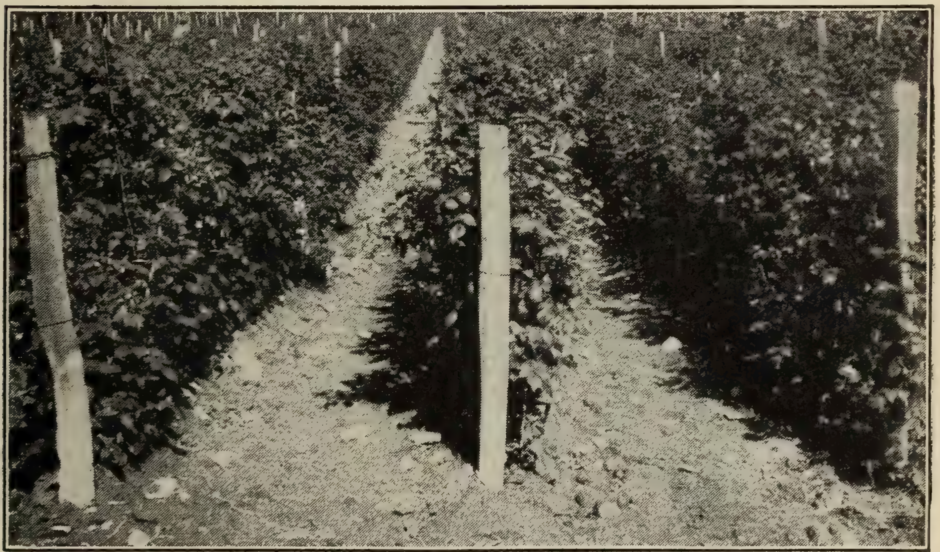


FIG. 227. Red raspberries grown in hills about 18 inches apart and trained to a wire trellis.

directions under "Fertilizing the Soil" for enrichment of the soil.

Have the soil in the best possible tilth for planting. This will hasten the planting operations, give the plants a better chance to establish themselves, and reduce later trouble with grass and weeds.

7. Determining the Planting Plan. Allow plenty of space for plants. What is plenty of space depends on the type, the variety, and the soil, but in general there is a tendency to set too closely, the amount of room the plants will take when the plantation is in full bearing not being appreciated. Put the rows far enough apart to permit team or tractor cultivation between them in one direction. There may be exceptions to this rule, but for commercial purposes it is often better to use more land, permitting quick and economical cultivation, than to restrict the area and increase the hand labor.

The *hill* or *hedgerow* systems (Figs. 226, 227, 228) may be

(*U. S. D. A.*)

FIG. 228. Red raspberries grown in hills and trained to stakes in the Hudson Valley section of New York.

followed, the latter being in commercial favor. Red raspberries and many varieties of blackberries sucker so freely that it is difficult to maintain the hill system, growers usually allowing the row to fill in in one direction, but keeping the width of the row restricted by plowing and cultivation. The hill system produces the larger fruits but the smaller total yield. It is easier to pick the fruit under the hill system. A modification of both systems sometimes called "*linear*" is to restrict the width of the row to the parent plants, but to cultivate only one way.

Red raspberries at 3 feet by 7 or 8 feet for the hedgerow system, or 5 to 6 feet apart each way for the hill system, represent standard practice. The hill system permits cultivation both ways and may reduce hand labor. At the distances given for the hill system only a single horse can be used. Departures from these recommendations should be governed by the fertility of the soil and the natural vigor of growth of the variety.

Black raspberries, although they do not sucker, possess a spreading and drooping habit of growth and need more space than might be thought necessary: 4 feet by 8 feet is about right, but some growers prefer 9 or 10 feet between rows.

The *purple* varieties are as a rule strong growers and need the maximum distances accorded the black raspberry. This also applies to the *blackberry.* If grown in hills, however, as it sometimes is, it may be set closer in one direction. The *dewberry* requires about 3 feet by 7 or 8 feet for the hedgerow system and 5 or 6 feet apart each way in hills, depending on the fertility of the soil.

8. Setting the Plants. Furrow the rows out in one direction. It will save time to cross-mark them the other way to determine the location of the plants, and to make it possible to cross-cultivate at least during the first season. Do not expose the roots to wind or sun. If the roots are puddled or coated with mud, this gives them added protection. Drop the plants just ahead of the planters, from pails or buckets containing a little mud and water. A dull, cloudy day provides excellent conditions for planting. Put the plants against the straight side of the furrow, cover the roots with soil, firming it with the foot, and turn back the remaining soil with plow or cultivator. It is good practice to set deeply, working the soil back gradually through the season. Do not cover the crowns of tip plants, or layers, of the black raspberry and the purple varieties, as this interferes with their development.

In setting black and purple varieties of raspberries, communication of anthracnose to the young plants may be prevented by removing and destroying the old stubs or canes which have no use except convenience in handling, and as markers for the rows.

The spade may be substituted for the plow in planting. Push it into the ground, work it forward, and insert the plant behind it, shaking out the roots. Remove the spade and firm the soil about the plant with the foot.

If the young plants have started growth, the buds and new shoots will be very soft and easily broken. Handle them with great care. It is evident that only strong, well-rooted, healthy plants should be used. Discard all others.

9. Managing the Soil.

Procedure:

(*a*) Cultivating the soil.
(*b*) Fertilizing the plants.

(*a*) *Cultivating the Soil.* Begin cultivation as soon as the plants are set. There is no substitute for it in the commercial plantation. The canes will not make vigorous growth or carry the crop to maturity without an abundance of moisture. Much of the root system is close to the surface. Grass and weeds rob it of water.

Whatever the type of row to be developed, cultivate both ways during the first season if possible. Finish with the hand hoe. Tilled or hoed crops between the rows during the first year may insure thorough care to the brambles themselves, and bring some return, though of course they increase the expense of cultivation. Raise crops adapted to the region for which there is use on the farm, or a market outside, except crops that necessitate stirring the ground late in the season, as late potatoes. The latter may induce growth of canes beyond the normal time limit, and increase the danger of winter injury.

After the first season, cultivation must be shallow, especially adjacent to the rows. The roots of the black and purple raspberries are barely beneath the surface, and in the red raspberry and blackberry, which sucker from the roots, the more the roots are broken, the more numerous will be the suckers that come up to plague the grower. With the latter fruits, the rows must be rigidly restricted in width or the suckers will gradually preempt the entire area. This can be done only by frequent and thorough cultivation. In the hill system the problem and solution are the same, except that the rows must not fill in between the hills.

The plantation will yield some fruit the second season—a considerable amount if all conditions have been favorable. Cultivate each year through the harvesting season to loosen the soil packed down by picking, and to conserve all moisture possible for the plants. If the plants droop over the cultivated area, they must not be disturbed when loaded with ripe fruit, or much of it will fall to the ground. In such a case, cultivate immediately after each picking.

Sow a cover crop in late summer, about mid-August in most sections, keeping the crop well away from the rows if it is one that lives over winter. Oats and barley, winter vetch, the clovers, cow peas, and soy beans possess merit, and under the proper conditions give good results.

Some growers secure good results by plowing toward the rows just deeply enough to turn the furrow before sowing the cover crop, and plowing away from the rows in the spring.

Mulching aids in moisture conservation and constitutes good practice where the cost of the material is not prohibitive.

Irrigation is necessary in some of the arid or semi-arid sections. The technique and practice relate directly to the needs of the particular section, and have been developed to meet them. In the Eastern states, overhead irrigation is valuable at times, when, in spite of good care, an abnormally dry season makes the lack of moisture the limiting factor in production. For the most part it is more to the point to maintain the supply of humus with its moisture-holding properties, and to cultivate frequently, than to rely upon irrigation.

(*b*) *Fertilizing the Plants.* The addition of organic matter is especially important in the fertilization of brambles. Moisture is often as much of a limiting factor to cane growth and fruit production as soil nutrients. Organic matter improves the physical condition of the soil so that its moisture-holding capacity is greatly increased.

Before the plants are set, a heavy application of barnyard manure should be plowed under and the soil thoroughly cultivated. Under many conditions the addition of 8 to 10 tons of manure per year and the turning under of cover crops will be sufficient to maintain vigorous canes and heavy fruit production.

There is very little experimental evidence relative to the fertilization of the brambles. Experimental results in New York, Oregon, and Rhode Island show that red raspberries respond especially well to applications of nitrate of soda. When this material is added, not only are more canes produced but also the individual canes are more vigorous and have larger leaves. Fruit production is also increased to some extent. From 150 to 300 pounds of nitrate of soda per acre are added, depending upon the soil and the growth of the plants.

The evidence relative to the fertilization of black raspberries, purple raspberries, and blackberries is very meager.

In North Carolina, two applications of fertilizer are generally made to dewberries after the first year. The first application is made just as soon as the canes have been tied up in the spring. The formula used varies somewhat in the different sections and with the different growers, but one that is often used consists of 2 per cent nitrogen, 10 per cent phosphoric acid, and 8 per cent potash. From 500 to 700 pounds per acre are used.

The second application is made immediately after the crop has been harvested and the canes cut off. Some growers use the same formula at this time, but since this applicatior is intended primarily to stimulate a rapid growth of vigorous new canes, a large proportion of nitrogen is favored by most growers. From 500 to 800 pounds of cottonseed meal plus 100 pounds of nitrate of soda, or 10 to 20 tons of manure, are often applied to the acre.

Apparently the most important thing to watch, especially in the North, is the application of too much fertilizer containing quickly available nitrogen which may result in making the berries soft and in causing such a late growth that injury by low temperatures may follow. It has recently been shown that a late summer cover crop, fertilized if necessary to produce a heavy growth, will assist materially in hardening the canes so they will better withstand low temperatures.

10. Pruning and Training the Plants. Pruning and training vary somewhat with the different varieties and fruits. The amount and kind of pruning necessary will be understood better if the method of growth is known. Each season new canes appear as shoots from the crown or roots and from buds near the bases of the previous year's canes. These new canes complete their growth the first summer, bear a crop the next year, and then die. They are then ready to be removed. The canes are biennial, but the roots live for several years and are perennial. It can thus be seen that, unless systematic pruning is practiced each year, the plantation will soon become choked with dead canes and there will be too many living canes for best fruit production.

Red Raspberries. The new shoots of the red raspberry should not be pinched or cut back in early summer. When these plants are pinched back, the new laterals formed are generally weak, are not very productive, and are often winter killed. After the fruit is harvested the old canes should be removed and burned.

In the spring, just before or as growth is starting, the weaker canes should be thinned out and those left should be headed back. If the hill system is used, from five to seven vigorous canes should be left per plant, but if the hedgerow is used about ten canes to every 4 feet of row should be left for fruiting. The amount of heading back depends upon the vigor of the canes, the method of training or support, the moisture-holding capacity of the soil, and the possible amount of rainfall during the growing season. Usually the canes should be left 4 to 5 feet high. The least amount of heading that will result in fruit of good size and still keep the fruit off the ground is desirable.

(*U. S. D. A.*)

FIG. 229. Wooden crosslegs with a wire on each side at the top held in place by bent nails, are used to support the canes in some raspberry fields.

A trellis is more generally used with red than with black raspberries. If a trellis is used, less heading back is practiced and greater yields are generally secured (Fig. 227). However, on account of the labor and expense of trellising, many growers prefer to head back the canes so they will be stocky enough to stand erect with the crop and to accept any decreased yields which may result (Fig. 226).

In some sections where the hill system is used, a stake or post is set at each hill, and the canes are tied to it (Fig. 228). The system of placing 3- or 4-foot posts at intervals of 20 to 30 feet and stretching two wires along cross-arms is also used where the narrow hedgerow or linear system is maintained. Other systems consist of using either one wire attached to posts as a support for the vines or, in some cases, two or three wires perpendicular to each other. The canes are then either tied or wound around these wires, or bent over and caught between the canes of the next hill as desired by the grower.

Black and Purple Raspberries. In order to prevent long, slender, weak canes, which bend over or break when heavy crops are borne, the new shoots of black raspberries are usually

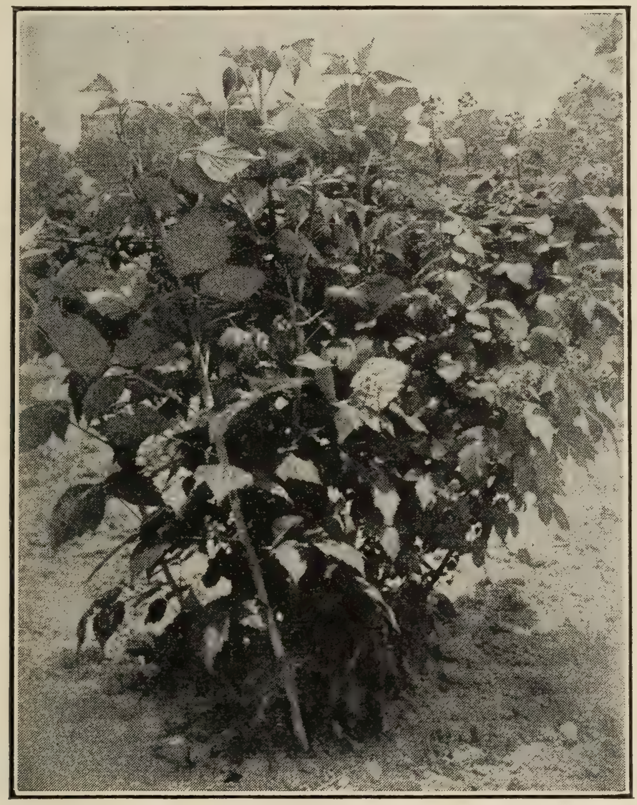


FIG. 230. Black raspberries with the new canes tipped in the summer.

pinched or cut off when they have reached a height of from 18 to 24 inches (Fig. 230). Since the purple raspberries often grow more vigorously, they are headed from 30 to 36 inches high. It is necessary to go over the plantation several times during early summer in order to pinch the different shoots when they have reached the proper height. The shoots should not be allowed to grow 4 or 5 feet before the heading back is done.

This heading back produces not only a stockier cane, but a cane with lower branches. The buds which produce much of the next year's fruiting shoots are borne on these branches.

The crop is borne for the most part upon new fruiting branches which grow in the spring from axillary buds along the laterals or branches. However, when the laterals are headed back heavily, considerable fruit is also borne from shoots which spring from the main cane.

The fruit buds on the laterals are generally so numerous on healthy plants that it would be impossible for the plants to develop the crop if all of them were left. As a result it is best to shorten these laterals in the spring just before or at the time growth starts.

Standard recommendations in the past have been to shorten these laterals, leaving them 14 to 18 inches in length, but it has recently been shown that the laterals of black raspberries can be headed quite severely without greatly reducing the total crop, while the size of the individual berries will usually be much better because of such severe pruning. Studies in Michigan show that, where laterals are headed back to four or six buds, excellent fruit is produced from these buds and also many fruiting shoots force out from the main cane. The individual fruits produced on the shoots which grow from the main cane are larger than those produced from the laterals. Other valuable evidence shown in these tests is that the yield from canes and from laterals, and likewise the size of berry, are closely associated with diameter or size of cane. Yields of individual fruiting shoots and likewise the average size of berry were also found to be closely correlated with the amount of foliage. It is stated, "The advantages of short pruning are more pronounced during ripening seasons that are characterized by low humidity and high temperature. It is to a degree an insurance against drought injuries."

It has also been shown at the Cornell Station that practically all the buds on black and red raspberry canes are potential fruit buds, although in blackberries there seems to be a greater likelihood of the basal buds being undetermined, or if forced into growth, of being vegetative.

Although there is practically no experimental evidence relative to the heading back of the laterals of the purple raspberries, it has been shown in Missouri that some varieties, such as Cardinal, produce fewer buds along the basal portions of the laterals than black raspberries. With such varieties it seems best to leave the laterals about 18 inches in length.

At the time of the spring pruning any weak canes should be thinned out. If the canes are vigorous, very little thinning should be practiced as thinning of vigorous canes will greatly reduce yields without materially increasing the size of berries. Likewise, laterals should not be thinned out, unless weak or diseased.

Usually, after the crop is harvested, the old canes are immediately removed and burned. In some regions where heavy snows occur the old canes are sometimes left as a protection to the new ones, but it is generally best to remove and burn them immediately after fruiting in order to destroy any disease which might spread to the new shoots.

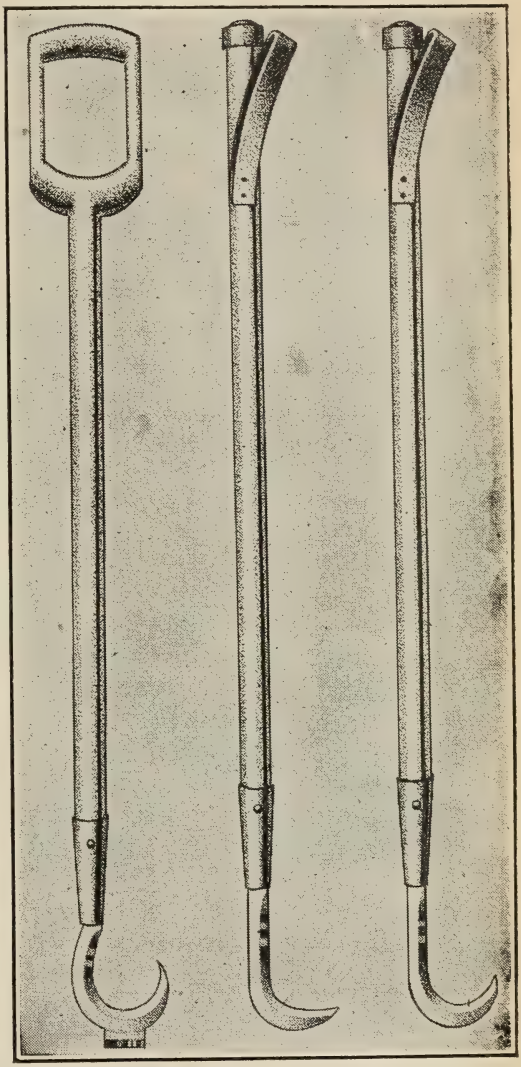
In many regions no trellises are used for black and purple raspberries. By shortening the new shoots in the summer and the resultant laterals in the spring, the plants become stocky and are able to hold up their crops without additional support. In some cases the new canes of each plant are bunched together and tied with a cord just beneath where the laterals emerge, thus helping to keep the plants erect. Occasionally trellises are used and then posts about 30 inches in height at intervals of 25 to 35 feet in the rows are employed. Cross-arms about 18 inches long are fastened to the posts, and No. 12 galvanized wire is stretched and fastened to the ends of these arms. This supports the fruiting canes and keeps the fruit out of the mud and dirt. In some regions, no wire is used, but stakes are driven into the ground at each plant and the plants are then tied to these stakes.

Blackberries. The pruning of the blackberry is quite similar to that outlined for the black and purple raspberries. The old canes should be removed and burned immediately after the fruit is harvested. The new shoots should be pinched or headed back early in the summer when they have reached a height of 24 to 30 inches. If the plantation is unusually vigorous, this height might be increased another foot. It is necessary during the summer to keep cultivating and hoeing out the new shoots which spring up between the rows or the plantation will soon become a thicket.

Fig. 231. Blackberries growing according to the hedgerow system. Red raspberries are also grown in this manner. The young canes have been tipped at the desired height in the growing season; red raspberry canes should not be headed back until the following spring.

In the spring, all weak and slender canes should be removed and only the strongest ones, about 10 inches apart, should be left. The laterals should also be headed back at this time. If there are several vigorous laterals on each cane, it will be well to head them back quite heavily, leaving them 8 to 10 inches in length, but if the laterals are not numerous lighter heading should be practiced. A recent Missouri bulletin shows that there are more basal fruit buds on the laterals of Early Harvest and Robinson than on Snyder, Eldorado, Taylor, and Rathbun. As a result it is suggested that the laterals of Early Harvest and Robinson should be shortened to 10 to 15 inches, while those of the other varieties should be left 18 to 24 inches long.

In some regions, no trellis is used, especially with the stockier varieties and where heavier pruning is practiced. However, in other regions and especially where the more vigorous and trailing varieties are grown, a trellis is always used. The type of trellis varies with the particular conditions or convenience of grower. Those described under red raspberries are also used by blackberry growers. The Evergreen Blackberry is trained to a four-wire trellis in Oregon and Washington and to a pole trellis 5½ feet high, or to stakes like dewberries, in New Jersey.



(*U. S. D. A.*)

Fig. 232. Pruning hooks, home made, used to remove old canes after bearing and to thin the young canes. These implements are about 34 inches long. The straps slip over the wrist. Somewhat similar hooks may be purchased.

Dewberries. Pruning and training of dewberries vary somewhat in the different sections. In North Carolina and other middle-southern sections, the plants are usually grown in hills 5 feet apart each way. In these regions both the old and new canes are cut off and the tops burned immediately after harvest. With thorough cultivation and the application of fertilizer, new shoots then grow vigorously and are allowed to trail on the ground. The following spring the canes are wound spirally about stakes at each hill and tied at about three places. The stakes are usually driven

2 feet into the ground and extend 5 to 6 feet above the ground.

Where the rows are from 5 to 6 feet apart and the plants about 3 feet apart in the rows, two plants are often trained to one post, which is located about half way between the plants. In some sections posts are located from 20 to 30 feet apart in

(*U. S. D. A.*)

Fig. 233. A Lucretia dewberry field in Michigan. The bearing canes have been tied to a wire and the ends cut off about 6 inches above the wire.

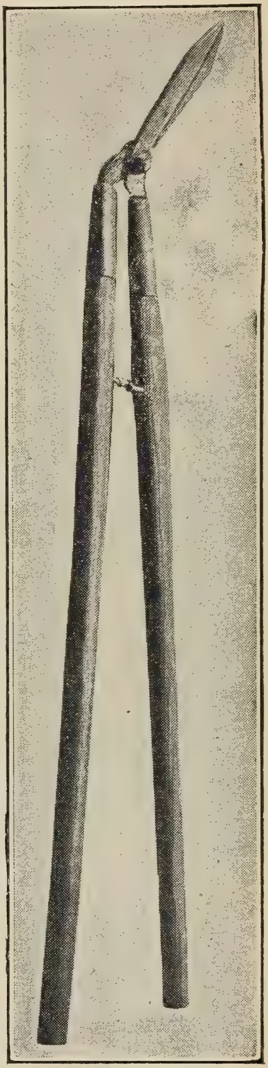
the rows, and along the tops of the posts is strung a wire to which the vines are tied up in the spring.

In some of the Gulf states no stakes or wires are used. The plants are set from 18 to 36 inches apart in the row and are allowed to form more of a matted row. Just before picking, the new canes are cut back so that they will not interfere with the pickers. After the crop is harvested the old and new canes are mowed as close to the ground as possible and when dry are burned without being removed from the field. This destroys many insects and diseases. Thorough cultivation is then practiced, and the new canes make a solid row for the next year's crop.

11. Controlling Diseases and Insects. The diseases and insects that trouble the brambles are relatively few, but some are very destructive. The grower should be familiar with the more important ones.

These are *anthracnose,* attacking all brambles, but especially virulent on the black raspberry; *cane blight,* also severe on black raspberries, but affecting all raspberries; *crown gall,* infecting chiefly red and black raspberries and blackberries; *orange rust,* destructive to blackberries and dewberries and occasionally to black raspberries; and *double blossom,* seriously affecting blackberries and dewberries in Southern sections. Follow the control program of the local experiment station.

The *mosiacs* and other virus diseases are very destructive to raspberries, especially red varieties in some sections. In parts of New York the industry has disappeared by reason of the inroads of these diseases. No parasitic organism has been discovered, but juices from an infected plant, when introduced into a healthy plant under proper conditions, will result in infection. Thus the term "virus" diseases.



(*U. S. D. A.*)

Fig. 234. These shears are in common use in some sections for pruning dewberries. The blades curve upward so that the operator may cut the canes close to the crown of the plant without much bending over.

An affected plant never recovers and parts taken for propagation are also diseased.

In red varieties the disease appears as a mottling and puckering of the leaves and dwarfing of the canes (Fig. 235); in black varieties the growing tips and young leaves are also killed. Plants of red and purple varieties are seldom killed outright, but the yield and quality are greatly reduced. Black raspberries are frequently killed. The diseases, which are carried by aphids or plant lice, are disseminated chiefly by winged forms and ants. They may also be carried on tillage implements. The *streak* or *blue stem* of black and purple raspberries is one of the virus diseases. Some varieties are resistant to the virus diseases; others are very susceptible. Cuthbert, June, Marlboro, Ranere, Columbian, and Cumberland are susceptible. Herbert, Latham, and Plum Farmer are less so, at least under many conditions.

(*W. H. Rankin*)

FIG. 235. The red raspberry plant on the left shows typical mosaic symptoms; the one on the right is normal.

Plant resistant varieties or those from disease-free fields. Use "certified" stock, that is, stock that has been rogued, and kept free as attested by competent plant disease inspectors representing a public agency. In some sections it will pay to eliminate or rogue the diseased plants during at least the first two years of the plantation. Take up the affected plants and remove at once. Do not leave them in the rows or about the field as the aphids will desert them for other plants as soon as they begin to wilt. Plant the rows far enough apart so that horses and tools do not brush the plants in tillage operations.

It is not contended that these measures will control in all sections, but they have been effective in some areas.

Among insects, the *tree cricket*, puncturing the canes, is sometimes serious; the *cane borer* girdles young canes and bores into the roots, the *crown borer* is very destructive in some western berry sections. The *raspberry sawfly* larvae feed on the leaves in northern sections and west to the Mississippi; the *raspberry beetle* causes many wormy red raspberries, and the *red spider* sometimes infests the brambles, causing the leaves to look yellow and sick. Each section has worked out control methods for those insects of local importance. Follow them, keeping in touch with new findings from year to year.

12. Harvesting and Marketing the Crop. The fruit of all members of this group is very perishable. It ripens quickly, reaches its highest point of excellence quickly, and deteriorates just as rapidly. These natural processes are accentuated by wet, sultry weather. The red raspberry is especially tender, and its period of use for consumption is short. Plans must be made well in advance to handle every detail of the harvesting and marketing operations promptly and efficiently. Packages must be on hand, pickers must be available, and the channels through which marketing is to take place must be clearly in mind.

Pick *raspberries* as soon as they separate freely from the bushes. They will then be firm and will stand handling and shipping better than if allowed to become fully ripe. Pick them only when dry; wet fruit goes down within a few hours from disease, settles greatly in the boxes, and is decidedly unattractive.

Pick the fruit with the greatest care, using the thumb and two fingers. Unskilled pickers hold quantities of fruit in the hand after picking, partially crushing it before it reaches the box. Place the berries gently in the box instead of dropping them from a distance.

Pick directly into the boxes in which the fruit goes to market. For red raspberries, these should be pint baskets, since the fruit is structurally so weak that if quart baskets are used the weight of the top layers will crush the berries in the bottom. Quart boxes are standard for black and purple berries and may also be used for the reds if they are to go at once to the canning factory.

Carry only a few boxes, from two to four, in a container tied around the waist or, better still, suspended from the shoulders, so that there is less danger of spilling the fruit as the picker leans over. A heavy apron folded up and caught

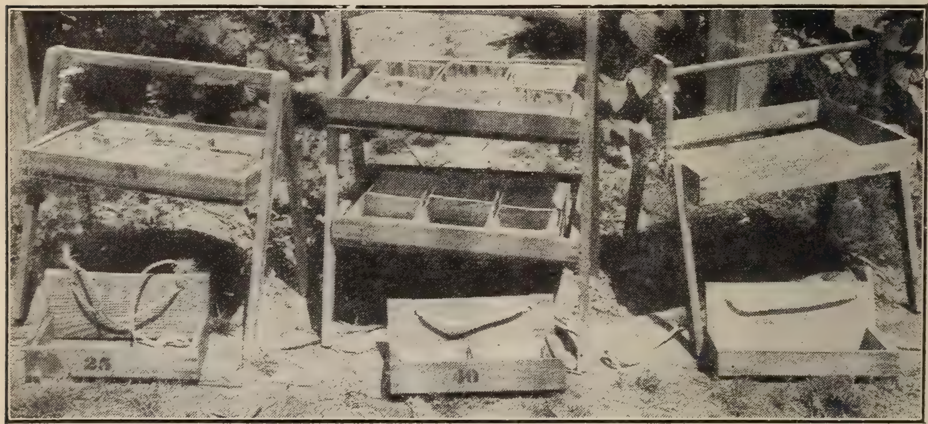


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Fig. 236. These various types of waist carriers and hand carriers, or stands, are used in picking the fruit.

at the corners with safety pins will hold several baskets. Two boxes are better than four, as the longer the picker carries the fruit about, the more it will settle in the boxes, the larger the quantity that will be required to fill them, and the more the fruit will depreciate in value. A basket of carefully picked fruit is largely air. It is poor business to replace this air with more berries by crude picking and handling methods, when the consumer desires the fruit in the original state.

Transfer the boxes from the carrier to stands or crates out of the sun, and keep the fruit in the shade and as cool as possible from this point until it is delivered for consumption or shipment. Avoid as far as possible picking in the full heat of the day, as the fruit will stand up much better if put into the boxes when cool. Do not run or grade the fruit further, as any gains in so doing are more than lost by added injury from handling. The picker must discard the over-ripe or undesirable berries as he goes along. Some growers have the pickers carry special boxes in which to place such fruit, putting it into local consumption the same day. From six to ten pickers per acre, depending on their proficiency and the picking conditions, will be needed.

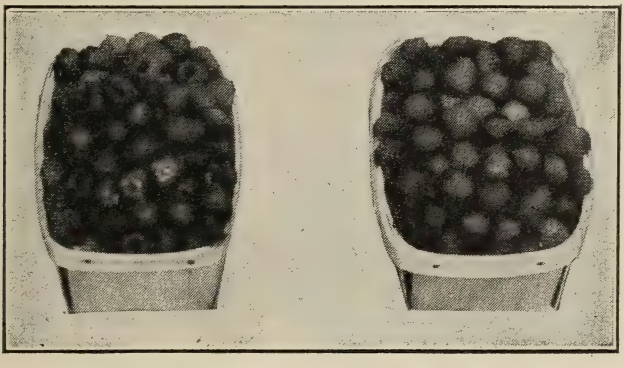


Fig. 237. These pint baskets of Cuthbert red raspberries are the same except that the basket at the right has been faced by turning the berries in the top layer. Facing makes a more attractive package, takes little time, and pays well for some kinds of trade.

Use the standard 32- or 24-quart crate for all except the red raspberries. The latter go best in pint boxes in crates holding from 16 to 24 pints. Use spring wagons or pneumatic tires for hauling.

Refrigeration is necessary for long shipments, and precooling is advisable. Red raspberries so handled from the state of Washington now come as far east as Pittsburgh.

In addition to use as fresh fruit, the berries are canned, or used for juice, jelly, jams, or syrups for soda fountains. Much of the fruit is now stored in casks or barrels after freezing, either with or without the addition of sugar, for later use. The flavor, when properly handled, is excellent, and considerable extension of this method of holding will take place as further improvements and perfections of the process are made. See "Frozen Fruit," page 148.

Harvesting methods for the *blackberry* and *dewberry* are essentially the same. Most varieties turn black, however, before they are ripe. If picked as soon as they turn, they are too sour to be agreeable, but of course they must come off while still firm. Keep entirely away from the sun, as the fruit becomes bitter when exposed to it.

(*U. S. D. A.*)

FIG. 238. A crate of Southern dewberries, packed for shipment.

Pay pickers by the hour, for a high-class product. The cost per basket will probably be greater, but the product should be worth more than enough additional to make up the difference. For the canning factory, or if using the help of neighbors or permanent residents of the community, the piecework basis may give satisfaction. In any event, personal supervision by some one in authority is necessary to insure clean picking, careful handling, and grading. A bonus payable at the end of the season will often hold pickers until the job is done.

For recording boxes picked, use the check or punch card system. A metal check may be given for each box or crate, to be redeemed on payday. A card properly designated with numbers may be given the pickers and punched by the superintendent upon delivery of the fruit. This system makes abuse and fraud easy unless the style of punch is changed frequently. A book record may be kept in lieu of the above systems, but the responsibility is then entirely on the operator, and misunderstanding and dissatisfaction are likely to ensue. It is better to make the picker share the responsibility by putting in evidence his check or card when he gets his pay. It is also evident that frequent paydays will help to keep things running smoothly.

Dried Fruit. In Ontario, Schuyler, and Yates Counties in New York, blackcaps are grown for drying. For the most part they are harvested by a special contrivance. A "harvester" or wide frame covered with burlap or muslin is pushed under the bush. The operator pulls the canes over the frame with a wire hook in one hand, and with the other he "bats" the canes with a light wooden paddle. The ripe fruit falls on to the frame. The plantation is usually gone over twice by this method. The leaves, sticks, etc., are blown out by running the dried product through fanning mills. Three to 4 quarts of fresh fruit make 1 pound of the dried product, depending on the variety and the condition of the fruit, whether dry and seedy or juicy at time of harvest. The dried fruit can of course be transported long distances and kept indefinitely. Red raspberries may be dried, but the shrinkage is very great and they are unattractive. The purple varieties are better for this purpose. However, with the advent of new and improved methods of canning and preserving, and storage, it is likely that the demand for the dried product will diminish rather than increase.

Life of Plantation. Berry plantations will last indefinitely if well tilled and fed, pruned regularly, and kept free from disease.

If grass and weeds invade the rows or sod forms about the roots, cane growth becomes weak and yields quickly fall below a profitable level. The black raspberry is as a rule the first to surrender. Winter killing takes a hand now and again. The prevalence of disease is often the limiting factor. Mosaic, anthracnose, crown gall, and orange rust will take heavy toll and must be fought constantly with some members of the group and in nearly all sections. By the setting of healthy plants, constant watchfulness, severe roguing when required, and intelligent spraying, the grower adds years to his plantation and augments his profits.

Yields. Yields vary with the kind of fruit, the season, and the section, in addition to the factors heretofore mentioned. The average yield of raspberries for the country is less than 1000 quarts per acre, but this is a poor measure for the good grower. In most parts of the country to which they are adapted, purple varieties yield the most, followed by blackcap and the red varieties in order. Perhaps 2500 quarts for *purple varieties,* 2000 quarts for *blackcaps,* and 1600 to 1800 quarts per acre for *red raspberries* represent reasonable standards under good care. Yields much in excess of these are not at all uncommon. In marginal territory to which these fruits are not well adapted, the yields may be much less. Under the special conditions of the Northwest and in sections of Colorado the yields of red varieties, chiefly Cuthbert, Antwerp, and Marlboro, run from 4000 to 8000 quarts per acre.

Blackberries and *dewberries* usually run from 2200 quarts per acre upward, under good management. However, since they ripen at the hottest and driest season of the year, the yield may be seriously reduced by unfavorable weather.

13. Protecting the Plants in Winter. Winter protection is necessary in some sections. Local experience is the guide. Protection is not occasioned so much by absolute cold as by frequent drying winds or by sharp temperature changes before the rest period has been fully established.

As the first and best protective measure, select hardy varieties. Beyond this, if the plants need partial protection, plow out a light furrow close to the row on one side. This will induce the canes to bend over easily. Take forks with long handles and push the canes steadily toward the side on which the furrow has been made until the ends of the canes touch the ground. Reversing the direction, plow another furrow back, throwing the soil over the ends of the canes to hold them in place. Several men or boys will be needed to assist the plowman Perform the operation after warm weather is over, but before the ground is frozen. The canes will still be supple and will bend with only slight breakage. If complete coverage is desired, smooth the furrow over the canes, plowing a second furrow if more soil is needed. Uncover the canes before growth begins in the spring.

In Idaho, according to the United States Department of Agriculture, a contrivance has been devised by the growers by which, if complete coverage is necessary, the work may be done cheaply and quickly.

GENERAL INFORMATION

I. Varieties

The varieties listed are of commercial importance in various sections. Selections should be based on local experience and the recommendations of competent official agencies.

Red Raspberry

A variety of red raspberry may be adapted to one particular district, but throughout the raspberry-growing region of the country there are standard red raspberry varieties. Cuthbert is a standard of quality, excellent for dessert, cooking, and freezing. Its lack of hardiness in northern regions, low productivity, small berries, and susceptibility to mosaic have caused it to be replaced to a large extent by Newburgh and Marcy, newer varieties which do not have these undesirable characteristics. Latham is widely grown; Taylor is highly recommended. Although good in many respects, both may contract mosaic. June is early and ripens over a long season; Chief, a firm, attractive fruit, is popular in some localities.

Ranere (St. Regis) ripens over a long season and is inclined to double bearing. Indian Summer, mosaic free and similar in habit to Ranere, produces a summer crop inferior to that of most commercial varieties, but in the autumn it bears another crop on the tips of the new growth. Golden Queen, of the Cuthbert type but yellow in color, is susceptible to mosaic.

Black Raspberry

Kansas and Plum Farmer are early. Gregg and Cumberland are mid-season varieties. Shuttleworth is an improved chance seedling of Plum Farmer which seems to be superior in every way. Bristol and Naples are two new varieties which are well worth trial. The ripening of Naples follows Bristol and lengthens the season.

Purple Raspberry

The dull, unattractive appearance of a purple raspberry is offset by the dark red color and rich flavor of the cooked fruit. Sodus and Columbian are standard varieties at the present time. Because of superior qualities Sodus will replace Columbian as soon as sufficient stock is available.

Blackberry

Eldorado is one of the best commercial varieties; Early Harvest is popular in the South, but it is very susceptible to orange rust; Lawton is grown on the Pacific Coast. Marvel is one of the leading varieties in Florida, and is promising for the South. Himalaya is important in restricted areas on the Pacific Coast, where it is very productive. It is easily injured by cold and difficult to train.

Mammoth, a dewberry hybrid and self-unfruitful, is popular in California but not hardy in the East. McDonald, another dewberry hybrid, also self-unfruitful, is grown extensively in Texas, Oklahoma, and Missouri. It ripens nearly two weeks before the usual blackberry season.

Evergreen is important in Oregon and Washington. It is only partially hardy in other sections.

Dewberry

Gardena is important in California. Lucretia is the standard in most sections. Mayes (Austin Mayes) is the leading variety in Texas; Premo is grown in North Carolina; Young is popular in Louisiana and worthy of trial in the South and on the Pacific Coast.

The Loganberry is grown extensively in California. It is not known whether it is a red sport of the dewberry, a hybrid with the blackberry, or possibly with the red raspberry. In any case it is now the name for a group rather than that of a particular variety. Members of the group are vigorous growers and very productive of large red berries. They are too sensitive to cold to be grown in the East. The fruit is valuable in the fresh state as well as in the canned and dried forms.

Boysenberry

Boysenberry (Boydsenberry), a result of crosses of the loganberry, raspberry, and blackberry, is rapidly gaining favor with the canning industry on the Pacific Coast. Although it was released for public sale only in 1935, the Boysenberry is being planted in the warmer bramble-growing sections. It does not seem to be popular in the northeastern area because of its tender growth. Being very prolific and bearing one of the largest berries of its type, it is worth trying in the home garden.

COMMUNITY STUDIES

1. Determine from the census and other available figures the important areas in the United States and in your own state for growing the fruits described in this section. What are the factors that have determined these areas?

2. Which of these fruits are grown commercially in your community? What in your opinion are the reasons?

3. Visit several growers. Determine:
   - *a*. Market served.
   - *b*. Soils, and management before planting.
   - *c*. Preference as to site.
   - *d*. Varieties and source of plants—whether certified.
   - *e*. Planting plan and distances—number of plants per acre.
   - *f*. Time of planting.
   - *g*. Method of planting.
   - *h*. Cultivation practices.
   - *i*. Use of fertilizers—what, when, how?
   - *j*. Cover crops—kinds, amounts, time of sowing.
   - *k*. Fruiting habits.
   - *l*. Method of pruning and training.
   - *m*. Insects and diseases—eradication or control methods.
   - *n*. Yield second year—third year—mature plantations.
   - *o*. Source and type of pickers—number needed.
   - *p*. Management of pickers—method of payment.
   - *q*. Field picking practices—containers, carriers, crates, handling of fruit.
   - *r*. Method of marketing.
   - *s*. Returns.

t. Winter protection.
u. Life of plantation—limiting factors.

4. Do the facts as obtained from the survey corroborate your judgment or opinion held before making the survey? Secure if possible complete cost studies and records on these plantations, or get estimates of growers.

5. Prepare a financial statement for a five-year period, beginning with the year of planting, for a five-acre planting.

6. List your recommendations for improvement of local practices and your reasons therefor.

7. Should the producing area in the section be decreased or increased? Why?

SECTION II. GROWING CURRANTS AND GOOSEBERRIES

Currants and gooseberries are cool-weather and moisture-loving fruits. Heat and drought of summer are of greater concern than the cold of winter. They are most at home in the northeastern United States and Canada. In the South the summers are too hot, west of the 100th meridian to the Sierra Nevada and Cascade Mountains the rainfall is insufficient, and in the Southwest it is both too hot and too dry for best development of these fruits. The producing territory tapers off without sharp demarcation. Its limits are altered or extended somewhat through irrigation, higher altitudes, and special factors.

New York, Michigan, Wisconsin, and Pennsylvania are the leaders in currant production, followed by the northern coast counties of California. The gooseberry may be grown a little farther south than the currant; the center of production is in Illinois, Missouri, and the states adjacent to them north and east. New York and Michigan are also important factors in production. The fruit of both the currant and gooseberry hangs well to the bushes, so that the picking season does not come with such a rush as with the other small fruits.

Jellies, jams, preserves, alone or in combination with other fruits, constitute the chief contribution of these fruits to our domestic economy. Gooseberry pies are popular where known.

Currants are famous as a source of pectin and for their jelly-making properties, but gooseberries are almost as good for these purposes, though less commonly used.

The red currant is the currant of commerce, but the white and black types have their special uses.

Because of their relationship to the white pine blister rust of five-needle pines, these fruits should not be cultivated in areas where these trees are important, except with most careful safeguards and the observance of governmental restrictions.

Consult the state nursery inspector or the state department of agriculture before planting currants and gooseberries. Quarantines and restrictive measures are in effect in various sections owing to the blister rust situation. These measures are changed from time to time. The cultivated black currant is considered a special menace. The problem of saving our white pines takes front rank as a national issue. Its solution requires the cooperation of all good citizens.

Operations:

1. Establishing the plantation.
2. Pruning and training the plants.
3. Managing the soil.
4. Controlling diseases and insects.
5. Harvesting and marketing the crop.

1. Establishing the Plantation. These fruits bloom very early in the spring. Protect them from frost damage by locating the plantation where the air circulates freely. This will also help in disease control, especially with gooseberries. In the southern extensions of the industry, select silt or clay soils and the cooler northern exposures to reduce the effect of the sun. A deep loam, very fertile and retentive of moisture, is the approved type for best results.

Prepare the soil thoroughly as for garden crops before planting, eliminating all grass. Manure or green crops to enrich the soil will be beneficial.

Plant in the Fall in Most Sections. As already indicated, growth starts very early in the spring. Fall-set plants will be established and ready to grow at the first coming of open weather. If planting in the fall is impossible, then do the work at the earliest possible date in the spring. It will often be wise to plow the land in the fall so that no time may be lost. In the northern states of the mid-western area, spring planting may be preferable.

How Plants Are Obtained. Strong one-year plants from a reliable nursery give excellent results. They may be obtained at nominal cost, and this is usually the best source from which to obtain them.

Currants root readily from cuttings. Take strong 8- to 12-inch shoots from the present season's growth, after the leaves drop freely in the fall. Set immediately, 4 to 6 inches apart in the nursery row, tamping the soil firmly about them, and leaving about two buds above ground. Even better results may be secured by burying the shoots bottom end up in a sand hill or storing in a cool cellar in moist sand until spring. Roots start at the buds underground. Under good conditions the plants may be transplanted to the field at the end of one growing season, or they may be left one more year in the nursery row.

Some American varieties of gooseberries also propagate readily from cuttings. With others and with the English varieties, which are also grown in America to some extent, mound layering gives much better results. Cut back the mother plants very severely in the spring. In midsummer a large number of succulent shoots will have formed about the base. Cover these shoots half way to the top with clean moist soil, working it down about the canes and stubs with a spade until a mound has been formed. These shoots will send out roots from the base. Remove the rooted shoots at the end of the season and plant in nursery rows, or allow them to remain in the mound another year, depending upon the vigor of growth. Young gooseberry canes will also root if bent down and covered with soil, permitting the top to grow upward. For home use, the suckers which spring up about the base of the old plants may be transplanted.

In case of nursery plants, open the bundles on arrival and heel in, in a cool, sheltered place, until ready for planting. If the plants and roots are dry, soak thoroughly for several hours before heeling in, and wet the soil thoroughly after the operation is complete.

Dark Red Varieties of Currants Are in Greatest Demand. For market purposes select varieties that produce vigorous bushes of an erect habit of growth, easy to cultivate and pick. Take into account productiveness, size and firmness of fruit, and compactness of clusters. Since the entire cluster of fruit is removed, instead of stripping the individual berries, it is desirable that sufficient space for the fingers exist between the first fruit on the stem and the parent branch so that the fingers may grasp the stem without grasping the fruit. Acid varieties are best for jelly making, but since the fruit is best picked green for this purpose, nearly any variety picked at the proper stage will make good jelly. White currants possess limited market value, but are esteemed for dessert use. The black currant, so popular in England, has but few devotees here, owing perhaps to its strong and peculiar flavor.

Wilder, Perfection, and Red Lake are probably the best commercial varieties grown at present in the Northeastern states. The Cherry currant is often a misnomer used for all sorts of red currants for want of a better name. The genuine Cherry currant, though widely grown, is not so desirable commercially as some other varieties.

To this list may be added London Market for the Midwest and Pacific Coast. All are hardy, with the exception of Wilder, even in the coldest sections of the United States.

White Grape and White Imperial are the leading white varieties. Boskoop Giant, Champion, and Naples are black varieties.

Practically all commercial varieties of currants and gooseberries are self-fruitful and therefore no provision need be made for cross-pollination.

Both American and English Gooseberries Are Grown. The former are, as a rule, more productive, hardier, more resistant to mildew, and are usually considered to be of better quality. The fruit of the English varieties runs larger in size, and there-

Fig. 239. This shows the distribution of the fruit on the currant wood. The largest fruit is on wood not over three years old.

fore commands a higher price. The custom in this country is to pick and use gooseberries while green. If permitted to ripen, many American varieties are of excellent quality. In Europe the gooseberry is commonly permitted to ripen and is eaten out of hand as a dessert fruit. Downing, Houghton, and Poorman among American varieties, and Chautauqua, Columbus, and Industry of the European sorts have given best results thus far. Some Canadian thornless varieties are being tested and may prove desirable.

Plant at Such Distances as to Permit of Horse or Tractor Cultivation. This is for economy of labor. Allow 8 feet between rows for the team or tractor or 6 feet for cultivation with a single horse. Plants are 4 to 6 feet apart, depending on the vigor of the variety and its habit of growth, in standard practice. Set the plants deeply, furrowing out the rows in one direction and finishing with the shovel. Follow the usual precautions for protection of the roots from sun and wind.

In the Hudson River Valley in New York, currants are commonly set between grape rows and also beneath the vines, all cultivation being done with a single horse or by hand. In other sections, they are frequently planted between fruit trees. A moderate amount of shade does not seem to interfere with productivity, as long as the fertility of the soil is maintained.

2. Pruning and Training the Plants. Currants and gooseberries are usually trained to the bush form. The best fruit is generally borne on one-, two-, and three-year wood; therefore wood older than this should be removed. Fruit is borne laterally on the one-year shoots and branches and on spurs of the two- and three-year-old wood. Although fruit is borne on spurs of older wood, it is generally smaller and poorer in quality.

After the first year's growth, any weak, slender, or low-lying shoots should be removed, leaving from six to eight strong shoots per plant. After the second year's growth, thin out the new shoots, leaving three or four. After the third year's growth, leave three or four new shoots and thin out three or four of the three-year-old branches. After this pruning there will be three or four three-year-old branches, three or four two-year-old branches, and three or four one-year-old shoots to bear the crop during the fourth year. From this time on remove all branches over three years old or those which have borne two crops from spurs and replace these by leaving three or four of the strongest new shoots.

Gooseberries often bear much more heavily on one-year-old shoots than currants do, and as a result in some sections the wood is removed after it is two years old, or after it has borne one year from spurs. Many growers, however, follow the pruning methods described for currants.

3. Managing the Soil. Give frequent and shallow cultivation. The roots are usually close to the surface. Cultivate more deeply the first year than later. The disk harrow on land free from stones gives good results. The horse or grape hoe will reduce hand work.

Crops may be grown between the rows and between the plants in the rows, if the situation is such as to make this a profitable method. The question is whether the increase in labor costs in handling the plantation will be more than offset by the returns from the crops. Unless land is too valuable, it is probable that such crops might better be grown on a separate field. On the other hand, it is possible that the fruit will receive better care if such intercrops are used. Garden crops require thorough cultivation and those for which there is a market should be considered.

After the first two years, the fruit plants will need the space. Continue the frequent cultivations. Follow with a cover or green manure crop of such nature as to work into the soil readily, since deep plowing is out of the question. Buckwheat, soy beans, oats, barley, and sweet clover are among the suitable crops.

Mulching may be substituted for cultivation in growing on a small scale. The mulch keeps the soil moist, which favors development of the bushes. To be effective, it must be maintained from year to year. Mice frequently girdle the shoots. This fact, in addition to the expense of the mulch, constitutes the chief disadvantages in its use.

Bush Fruits Usually Respond Well to Applications of Manure. There is very little experimental evidence available relative to the kinds or amounts of commercial fertilizer which should be applied to currants and gooseberries. Wherever tests have been made, barnyard manure has generally been equal or superior to commercial fertilizers, especially with gooseberries. Where manure is applied, from 8 to 10 tons per acre should be used yearly. If plenty of manure is available at a low price, it will no doubt pay to use more, but if cover crops are turned under each year, less manure will be needed. Many growers add wood ashes, 800 to 1000 pounds, and 100 pounds of muriate of potash per acre in addition to the manure. In some sections from 500 to 800 pounds per acre of a fertilizer analyzing 4 per cent nitrogen, 8 per cent phosphoric acid, and 4 per cent potash are used apparently with good results.

It may pay bush fruit growers to test the different fertilizer elements, singly, and in various combinations in a small way on their own farms. In the absence of specific experimental data for the various regions general recommendations may not apply and may involve both waste of time and money.

4. Controlling Diseases and Insects. Leaf Spot and Powdery Mildew are sometimes destructive. Among insects the San José scale, the currant worm and the currant aphis are important. Follow the control program for the region in which the planting is located.

5. Harvesting and Marketing the Crop. Harvest currants while still somewhat green for jelly, but for other purposes they should be ripe. The pectin content which promotes the formation of jelly is higher in the unripe fruit. For other purposes pick them while still firm and only when dry. The picking season extends over a longer period than for the other small fruits. Remove the entire cluster, grasping the stem between the cane and the first currant on the stem, taking care not to press the berries. The cluster can usually be removed best with the thumb and two fingers. Quart baskets and 24- or 32-quart crates for general market and 6- or 8-pound grape baskets for the cannery are standard.

The currant may be held a short time in cold storage, but it soon molds if the air is damp. A dry, airy place is best.

Pick gooseberries after they reach full size, but before they are fully ripe. When Americans use them more as a dessert fruit, then the English method of permitting them to reach full maturity before harvesting will be followed. Wear leather gloves for protection from thorns.

Strip the fruit from the bushes for the canning factory. Run it through an ordinary grain fanning mill to remove leaves and refuse. Some growers prefer to use a scoop similar to a cranberry scoop for picking.

For the general market and retail trade, stripping causes too much injury to the berries. Grow the larger varieties and pick them by holding the cane in one gloved hand and removing the fruit with the other, also protected by a glove excepting the ends of the fingers.

Keep gooseberries out of the sun as they scald or discolor very quickly. Packages are the same as for currants, excepting that third- or half-bushel baskets are commonly used for canning stock.

Bushes Begin to Bear after the First Year's Growth and Should Reach Full Bearing at Four or Five Years of Age. In Northern sections on the heavier loams and under good treatment, including regular pruning, plantations yield profitable crops for ten to twenty years. In the Southern sections, and on sandy soils—unfavorable conditions of soil and climate—their life is much less. The grower may expect 100 to 150 bushels per acre from gooseberries, and higher yields in the best years. Yields of currants are rather less and are often more variable.

The plants need no winter protection. However, in sections subject to continuous drying winds, a windbreak is desirable. In regions of heavy snowfall, tie the canes together in an erect position in the fall so that the snow may not force them into a prostrate position, inconvenient for tillage and picking.

COMMUNITY STUDIES

1. Prepare a brief covering the life history and control methods of white pine blister rust.

2. From this point follow the outline under local studies for the brambles.

3. On what age of wood is fruit borne—the best fruit? Prune at least two currant and two gooseberry bushes.

SECTION III. GROWING THE CULTIVATED BLUEBERRY

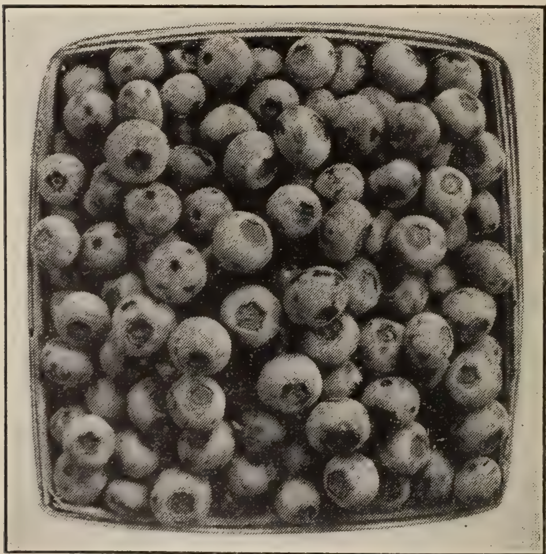
Growing blueberries under cultivation is a comparatively new practice. Unlike most of our common fruits, unimproved strains of wild blueberries are sold in direct competition with the cultivated varieties. Cultivated fruit may, however, be found on almost any wholesale market in Northeastern United States. Both the high- and low-bush forms of the blueberry or huckleberry, as it is sometimes called, are found growing wild in Northeastern United States as well as in Florida, Michigan, Illinois, and to some extent along the West Coast.

The fruit is used in the fresh state, but one of its chief values is for blueberry pie, a luxury that to foreign tables typifies American cooking.

Under the supervision of Dr. Coville, the United States Department of Agriculture began collecting wild strains in 1906. By cooperating with experienced pickers in blueberry districts, and with the owners of large patches, he was able to select several plants which possessed desired qualities. He looked for stiffness of branch, ease of picking, small dry stem scars, flavor, seedlessness, and keeping qualities. By controlled breeding and selecting he eventually concentrated as many as possible of these qualities in a single plant. At one time three hundred seedlings which were producing fruit larger than ¾ inch in diameter were destroyed because they lacked some of the other desired qualities. As a result of this work we have about ten good varieties. Although some of them are not so sweet as some wild strains, as a group they constitute

(*U. S. D. A.*)

FIG. 240. A quart of wild blueberries.



(*U. S. D. A.*)

FIG. 241. A quart of hybrid blueberries. Contrast with Fig. 240.

a collection of the best qualities which the plant breeders have obtained in fifty years of plant improvement.

Operations:

1. Selecting the soil.
2. Establishing the plantation.
3. Pruning the plants.
4. Controlling insects, diseases, and birds.
5. Harvesting and marketing.

1. Selecting the Soil. The ideal blueberry soil is fertile, well drained and aerated, acid, and well supplied with organic matter, and it has a plentiful water supply. Any soil in which wild blueberries grow is satisfactory for the cultivated crop. It may be improved by the addition of peaty material, moisture, or drainage. Any moist sandy loam can be made into a good blueberry soil with the addition of the proper organic fertilizers. Heavy clay soils are not satisfactory.

The *p*H of soils for best growth should be between 4.4 and 5.1. Sulfur, aluminum sulfate, sawdust, apple pomace, rotted wood, and acid peat have been used to produce acid soil conditions. Some are only good for back yard production. Rotted oak leaves are used most commonly.

The water table in a blueberry field is of vital importance to the success of the crop. If the land is wet, it should be drained so that the water table will remain about 14 inches below the surface. Lack of moisture reduces fruit bud formation; too much moisture will cause the leaves to fall off and the plant to die. The plants will tolerate standing water in the dormant season, but during the growing season an excess amount of water is fatal.

2. Establishing the Plantation. The soil should be well cultivated, the low spots either filled up or drained. If it is allowed to lie fallow for the first year, disking will help to control the weeds.

Two-year-old blueberry plants may be obtained from any nursery that specializes in growing them. If well grown, they should develop fruiting growth in two more years. It is much cheaper in establishing a large acreage of blueberries, however, to buy one-year-old plants. The method of propagation is covered in Chapter VII.

Cabot is an early variety and a good producer. It has a spreading habit. *Rubel, Rancocas,* and *Katharine* are later varieties which are more upright in stature. *Pioneer, Concord,*

(N. J. Agr. Exp. Sta.)

FIG. 242. Blueberries, showing planting plan and method of cultivation. These have been planted about 4 feet apart in rows which are 8 feet apart.

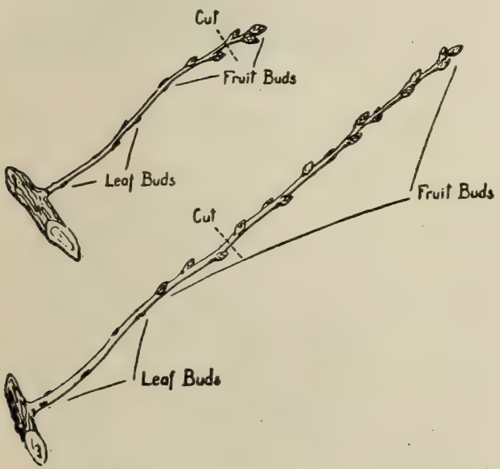
and *Jersey* are all worthy of mention. They have a much better flavor than *Sam, Rubel,* and *June.* Although the varieties all appear to be self-fertile it is believed that better crops can be obtained by using more than one variety in the same planting.

Plant as early as possible in the spring to take advantage of moisture. Various recommendations are given for distances, the average being about 6 feet apart on the square (Fig. 242).

The holes should be made large enough so that the root system will not be disturbed in planting; peat moss may be incorporated with the soil around the roots of the young plant.

After planting, the area around each plant should be heavily mulched with peat moss or decayed oak leaves.

An application of mixed fertilizer at the rate of 500 pounds to the acre is sufficient to promote good growth for the first few years. Insufficient experiments have been carried out to obtain any uniform recommendations. Increasing amounts of balanced fertilizers as the plants increase in size is all that can be advised at this time.



(*N. J. Agr. Exp. Sta.*)

FIG. 243. Showing position of fruit and leaf buds and amount of heading back needed. Varieties are Cabot and Sam.

With the use of heavy applications of mulch three or four shallow cultivations are sufficient to keep the soil in good condition during one season.

3. Pruning the Plants. Pruning the high-bush blueberry when it is grown under cultivation is a very important practice because this operation very largely controls the size of the fruit.

The different habits of growth of different varieties influence the type of pruning. The fruit is always borne on the previous season's growth. The aim, therefore, is to invigorate new growth, and this is done by removing a great deal of the old wood.

For the first two years after planting, all that is necessary is to remove the bushy growth and flower buds. The fourth year, severe pruning should be started (Figs. 244, 245, 246, 247, 248, 249). One or two of the oldest trunks should be cut

(*N. J. Agr. Exp. Sta.*)

Fig. 244. Rancocas after two years in the field.

(*N. J. Agr. Exp. Sta.*)

Fig. 245. Rancocas pruned.

(*N. J. Agr. Exp. Sta.*)

Fig. 246. Cabot in bearing which has been well pruned.

back to stumps, about 2 inches long at the crown. This will cause new shoots to start. Each year about a third of the oldest wood is removed; thus none of the wood in the bush is ever more than three or four years old. This is only a general rule to follow. If heavy sprout growth takes place from the old wood, a different type of pruning is advised. The low branches are removed because the fruit may become dirty from splashing soil during rains or from wind-blown debris. Crowding branches in the middle of the bush should be removed. This will expose the fruiting wood to more sunlight and give more even ripening of the fruit as well as easier picking.

(*N. J. Agr. Exp. Sta.*)

Fig. 247. Cabot in bearing that has not been pruned. Compare with Fig. 246.

The older and larger blueberry bushes must have considerable "tipping" done to the terminal growth. The fruit buds are much plumper than the leaf buds. Each bud will produce from eight to fourteen berries, if properly pollinated. New shoots do not need much tipping back, but the laterals on the older branches should be cut back to three or four fruit buds.

If plants are neglected they will reach a stage where no vigorous growth takes place. Cut back the entire top to the crown in the spring. A new bush will grow that summer, and the following year a crop of fruit will be borne.

Prune in early spring.

4. Controlling Insects, Diseases and Birds. If the bushes are pruned annually and kept growing vigorously, there is

(*Mass. Agr. Exp. Sta.*)

FIG. 248. Pioneer before pruning.

(*Mass. Agr. Exp. Sta.*)

FIG. 249. Pioneer after pruning.

very little danger from insect and disease injury. Stem borers are reported in Massachusetts and New Jersey. They are controlled by removing and burning affected parts at picking time. A few other enemies, as the blueberry fruit fly, Japanese beetle, cranberry fruit worm, red-striped fireworm, red-humped caterpillars, twig blight, and "mummied fruit" have been known to attack the blueberry. If any of these become serious, consult the local experiment station.

Birds are very bothersome on small plantings. The only satisfactory way to control them is to cover the bushes with cheesecloth.

(N. J. Agr. Exp. Sta.)

FIG. 250. Rubel in its fourth summer in the field.

5. Harvesting and Marketing. Pick the fruit once a week under normal conditions. The fruit must be blue for about a week before it is ripe. The ripened fruit is blue close up to the stem. The clusters ripen unevenly and therefore the season lasts from three to seven weeks. The average yield for New Jersey is 1600 quarts per acre.

Berries are usually picked into pint and quart boxes (Fig. 250) and packed into crates, like strawberries or raspberries. Sometimes they are picked into pails and later transferred to boxes for marketing. All the leaves, twigs, and shriveled berries are removed and the well-rounded boxes covered with cellophane. Blueberries will keep in cold storage for about two weeks and can be shipped long distances without deterioration.

CHAPTER XV

SHALL I BE A FRUIT GROWER?

Unlike many types of agricultural production, fruit growing is decidedly a long-term proposition. In contrast, the individual deriving a major part of his income from annual crops may usually change to crops other than those which he has been growing, provided that there is indication that the change will be more profitable. Such is not the case with the fruit farmer, for once the fruit plantation is established, only through a sacrifice of values, capital and effort, can he change his field of endeavor. Were it possible to look into the future at sufficient length, many of the problems and hazards associated with fruit growing would be eliminated. The long period which usually exists between the planting and harvesting of a fruit crop tends to intensify the risks which the individual engaged in this type of agriculture must take. There is every need for the closest consideration of the factors which may affect the profit-making ability of the enterprise. The multitude of situations over which there is no control serves but to emphasize the necessity for careful investigation of all available information in guiding one's decisions in the selection of a vocation.

The potential fruit farmer should not be content to base his decisions in choosing a vocation solely on the probability of financial return. To be sure, this is very important, but few men have the will power to make a success of a business in which they have no personal interest. The following questions should be answered:

1. Have I a sincere personal interest in the problems concerned with the management and operation of a fruit farm?

2. Can I expect over a long period that the enterprise will pay me a reasonable return in proportion to the labor and capital expended?

Too much emphasis cannot be placed on the importance of the first question. Too often, the anticipation of monetary income tends to overshadow the personal element involved in the selection of an occupation. Income takes many forms. Reasonable satisfaction in the work and the job, the opportunity to do the things one likes to do are not to be underrated. There is not much point in seeking the answer to the second question until the answer to the first is known. If the individual is undecided, he would do well to work on a good fruit farm before going further with his analysis of the situation.

Perhaps the individual is faced with the choice of many occupations. It is possible that he believes that fruit growing is the thing he likes best. How then, can he be fairly sure that this is the type of agriculture that he will most enjoy? Perhaps a fair answer to a series of key questions would assist in putting him on the right track.

1. *Is my interest in fruit growing based on actual experience?*

The chances are that a person who has spent a part or all of his life on a fruit farm will be in the most advantageous position when it comes to determining whether or not his enthusiasm is well founded. However, this does not mean that the person who has had no great amount of experience cannot hope to make a success of the enterprise. There is every reason, however, why he should arrange to spend a season or better still three of four seasons on an up-to-date fruit farm to determine his aptitude and liking for the work.

2. *How does my interest in fruit growing compare with my interest in other agricultural enterprises, i.e., dairy farming, poultry raising, production of cash crops, etc.?*

Here, again, the experience in any given field is likely to have resulted in certain prejudices for or against certain farm enterprises. This may be advantageous. The young man who has a keen dislike for hens certainly would not be content raising poultry even though there was considerable promise of profit in the field. Undoubtedly, many have left the farm for what appeared to be greater attractions in the city who would have remained in agriculture could they have found a phase which held the necessary attraction for them.

3. *Would I be willing to undergo cheerfully the limitations connected with fruit production?*

In the cultivation of fruit, as in practically all other agricultural pursuits, there are times when one has to sacrifice hours of leisure when the majority of the population is at rest to attend to the needs of the enterprise. While fruit growing may not be so confining as dairy farming, there are periods when the hours are as long, the work as hard, and the tasks as repetitious. The finished product may be beautiful and delightful, but it involves many hours of labor and sweat and uncertainty.

It has been said that a good teacher can determine a student's aptitude for an enterprise by the manner in which the student appraises its products. Given an apple, the recipient is likely to have one of two things in mind—the quality of the fruit and the care used in producing it, or what it will do for his stomach. The man with a love of fruit growing in his heart will see the orchard in bloom and all the various operations that lie between. He will have a fine regard for the finished product.

The objective to this point has been primarily to assist the individual in determining the origin of and subsequently the soundness of his conclusion as to choice of occupation. With this analysis completed, it is in order to turn our attention to the second consideration, "Can I expect to make a reasonable living through the production of fruit crops?" This may be considered under several headings and from several standpoints.

The gross income of fruit farmers is often higher than that of farmers engaged in other types of agriculture (assuming comparable investments), but so are the expenses. It must be remembered that it is not the gross return but rather the margin of profit which determines the final or net income from the enterprise. As an illustration, the following figures obtained from New York State farms on which cost accounts were kept from 1934 to 1937 inclusive are of interest. Compiled by the New York State College of Agriculture, they show average gross returns, costs, and margins above costs of various fruits and of fruits as a whole compared with comparable units of certain other crops. Apple prices were perhaps unusually low at the time. Since fruit growing is such a long-time undertaking, comparsions over a more extended period, perhaps ten years, would be more reliable.

	Gross Returns	Costs	Margins
Fruits			
Apples	$126	$117	$ 9
Cherries	223	118	105
Peaches*	66	45	21
Pears	54	52	2
Average, 4 fruits	$117	$ 83	$ 34
Cash Crops			
Cabbage	$95	$69	$26
Canning peas	39	41	−2
Potatoes	96	84	12
Canning tomatoes	100	83	17
Average	$83	$69	$14

* Three years, 1935–37.

Capital. Planting and caring for an orchard properly until it begins to yield a return at least sufficient to meet current expenses require considerable capital as well as patience. The time which must elapse between planting and bearing will vary with the type and variety of fruit and with the location of the orchard.

TIME ELAPSING BETWEEN PLANTING AND BEARING STAGE OF COMMON FRUITS

Apples	7–15 years	Raspberries	2–3 years
Pears	7–15 "	Strawberries	1+ "
Cherries	5–8 "	Grapes	3– "
Peaches	3–5 "		

If the grower plants his own orchard, his capital must be tied up for some time before he can expect returns. Few are likely to be so fortunate as to have capital to carry over to production, which means that some other source of income must be available during the intervening period.

The preceding paragraph should serve to point out the need for a considerable amount of capital at the outset or reasonable assurance that there will be some additional source of income during the non-bearing stage. Good soil is imperative. It would be folly to buy cheap land with the idea that costs could be kept down. It has been found that a definite correlation exists between type of soil, size of orchard, and labor income. As labor incomes tend to increase with increased acreage on good soil, so does labor income tend to decrease when an attempt is made to increase acreage on poor soil.

One point has thus far not been mentioned, namely, the advisability of purchasing an orchard which has already reached the bearing stage. This has some advantages. Orchard land generally has shown some decline in value during the past ten years. There is some evidence that a young orchard surrounded by reasonably good conditions might be an economical purchase. However, it is essential that the buyer spend some time in determining the reasons behind an offer for sale. A desire on the part of an individual to sell may not always be caused by failure to make a profit, and, conversely, it may be that the type of soil, variety of trees, etc., make the possibility of converting the business into a profitable enterprise out of the question. The value of experience behind the planting of a new orchard or the purchase of a "going concern" cannot be underestimated. It is most essential if the individual is to judge fairly what he is getting for his money.

The original capital investment cannot be neglected in computing the cost of producing the fruit. High land values can be as instrumental in eating up profits as any other one factor. While it does not pay to buy poor land, it is equally important to "get your money's worth."

Cost of Production. Though the price which fruit is to bring can hardly be estimated with any degree of accuracy, there is some possibility that the cost of producing the fruit can be determined fairly well. This is true because some expenses will occur each year with little variation. They are as important as they are unavoidable, and they serve, in more cases than not, to determine the financial success or failure of the enterprise. Since they vary little, and certainly, over a short period, show little relationship to the fluctuations in the income, the expenses are commonly termed "fixed costs." They are

1. Interest on investment.
2. Depreciation.
3. Taxes.
4. Insurance.

Interest on investment reflects the original cost of the land. While interest rates have shown some decline over the past 80 years, the value of the land has increased sufficiently to more than outweigh this advantage. Land is but a part of the total investment. A significant part of the permanent capital is tied up in buildings and equipment. It is of equal importance that the interest on the money used to carry these items also be included.

Depreciation takes place on the trees after they have reached maturity as well as on the buildings and equipment. Conservative rates for estimating these costs are:

Trees: 3-8 percent, depending on the kind of fruit and the probable length of profitable bearing.

Buildings: 3–5 percent, computed on cost.

Equipment: 10 percent, computed on cost.

While these costs may not necessarily represent an equivalent outlay of cash, they must be considered if a fair estimate of the net income from the enterprise is to be obtained. Remember that interest on investment represents only a fair return on capital if it were placed in some other business. It is intended that charges made for depreciation will, over the estimated period of useful life, equal the original cost of the item. It is not fair to consider the purchase of a sprayer as an expense of the year purchased, and neither is it just to consider it an expense of the year when it is discarded. The cost can be allocated fairly only over the period of actual use.

Taxes and insurance, in contrast to interest and depreciation, represent actual outlays of cash. Neither shows any short-run relationship to the commodity sold.

The bulk of the variable expenses assumed by the orchardist each year relate to labor, fertilizer and spray materials, and marketing supplies. Each requires an actual cash outlay. There is a minimum of expenses below which no orchard can be kept in condition. It is difficult to determine how much should be paid out for these items without knowing what the returns will be. It is not good business to spend more on packaging the fruit than can be expected in return. On the other hand, the long-run value of turning out a top pack of fruit and building a reputation thereby may serve to repay the grower many fold for a large initial outlay.

Purchasing Power. The fruit farmer, like any business man who is engaged in the production of products for resale, can be financially successful only when the relationship between the things he sells and the things he buys is to his advantage. This is known as purchasing power. The apple producer is not so much interested in the price of the fruit as he is in the number of bushels of apples or crates of berries

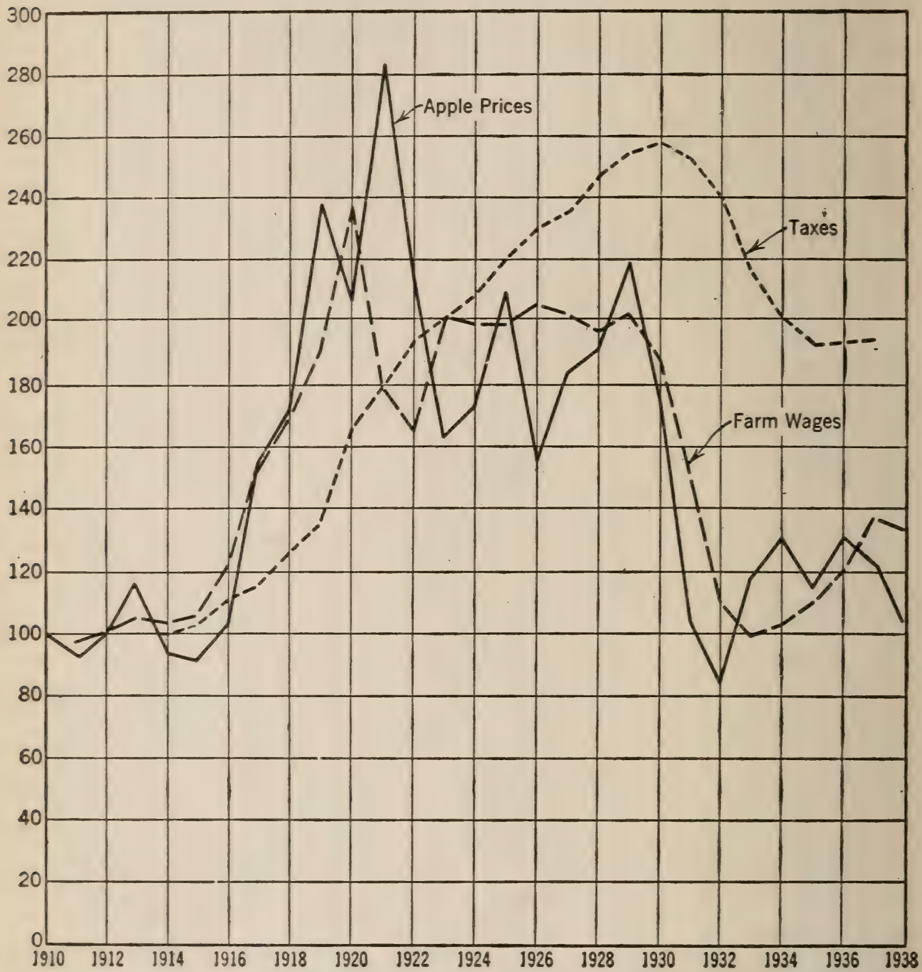


FIG. 251. The relationship of apple prices to taxes and wages determines to a large degree how high these prices really are.

it will take to pay the taxes, to purchase a spray rig, or to buy a sack of flour. It has been pointed out that there are certain fixed costs which over a period of a few years do not vary significantly. It does stand to reason then that the fruit grower is interested in the price which he can get but only so far as it will tend to give him a greater advantage in paying for the things which he buys. Figure 251 will serve to point this out. It details the relationship between the farm price of apples, taxes per acre of farm real estate, and farm wage rates in Pennsylvania for the following periods: apple prices, 1910-38; taxes, 1913-37; wage rates, 1911-38, taking apple prices and wage rates as 100 from 1910 to 1914 inclusive and taxes as 100 in 1913. The information was compiled by the Pennsylvania Agricultural Experiment Station.

Taxes on farm real estate show very little relationship to the price of apples. It will be noted that in 1921, when apple prices were at the peak for the 29-year period, taxes were not comparatively as high. In contrast, taxes reached their high point in 1931, one year prior to the low point in the price of apples.

Farm wage rates present a somewhat different picture. There is a marked correlation between the cost of farm labor and apple prices. Wages do not fluctuate so violently and tend to lag a year or two behind changes in apple prices. It can be expected that orchardists would use less labor in years following low prices and somewhat more labor in years following high prices.

To a significant degree, the relationship existing between farm wages and apple prices is representative of many variable costs. Conversely, the lack of correlation between tax rates and apple prices may be considered representative of fixed costs. The conclusion may be drawn that the constant expenses in fruit production are the ones which are likely to create financial problems in the face of low farm prices. This further emphasizes the need to keep fixed costs at a minimum through careful planning at the time the young fruit farmer goes into business.

The purchasing power of individual commodities tends to be affected more by the price which that product brings than by the cost of producing the product. That is, there are certain fixed costs in all the agricultural industries which vary little, one from the other. On the other hand, the prices which farmers get for their products may vary considerably among those items which are produced for sale.

The price of peaches in a given year may be fairly high because of a late frost in Georgia while a surplus of apples may have caused the unit value of that crop to be low. Even more pronounced may be the spread existing between fruit, truck crops, and dairy products. It must be remembered that these differences in price are yearly phenomena. All agricultural products tend to follow each other in price relationships over a long period. It is doubtful that any one crop possesses any particular advantage over a long span of years.

Diversification. This brings us to the consideration of the advisability of planting more than one crop. The advantages of such a program are twofold.

1. It gives the young orchardist who is planting his own orchard an opportunity to derive some cash income until his trees reach the bearing stage.
2. It contributes considerably to uniformity of income by reducing the risk of crop failures and low prices.

Diversification tends to take some of the gamble out of fruit raising. The grower is not "putting all his eggs in one basket." However, there are some factors which tend to limit the number and types of enterprises which a farmer can handle economically. Care must be taken to choose those enterprises which do not conflict with one another in receiving the attention which they demand. The units must be large enough to permit economical operation. The commodities to be produced should be ones which can be raised profitably in the area. Many fruit growers in western New York raise feeder lambs and beef cattle, not because the return from these enterprises is high but because they are making a little money this way that would not be obtained otherwise. Indirect benefits may be derived even though no actual cash profit is made.

Summary. It is important, then, that the young man who is contemplating the production of fruit crops as his life work consider carefully the following factors:

1. The basis of his interest in the work.
2. The capital requirements.
3. Planting a new orchard *vs.* purchasing one already established.
4. Factors affecting the margin of profit.
5. Prices in terms of purchasing power.
6. Possibilities of diversification, its effects on purchasing power.

He must line up the fields in which he entertains some interest squarely before him and subject them to careful analysis. The age of trial and error is over in establishing orchards. Unprofitable orchard sites are being abandoned for those which have proved their worth. With increasing costs of fruit production, with no corresponding increase in prices, the margin of profit shows a tendency to diminish. In spite of this, opportunity remains for him who chooses a favorable site in a suitable region and farms intelligently to make a good living from this enterprise.

It is evident that the efforts of the fruit farmer will be directed toward the type of production which will yield him the maximum return. He is not interested so much in gross receipts or expenses taken independently as in the margin which exists between the two. This is his profit. This is the thing that can be exchanged for the goods which serve to provide him with some of the necessities and satisfactions of life. Before most other things, he must be certain that he will obtain a maximum degree of enjoyment from the work he is doing. This last point is worthy of stressing over and over again. Large profits cannot be expected from agriculture. This makes it all the more important that the individual find satisfaction in its pursuits. There will be years when that, in itself, will constitute the chief return from his labor.

APPENDIX

SCIENTIFIC NAMES OF SOME OF THE SPECIES OF OUR COMMON FRUITS

Common Name	Scientific Name
Apple	*Pyrus malus*
European or Common American Pear	*Pyrus communis*
Chinese or Sand Pear	*Pyrus serotina*
Snow Pear (grown somewhat in Europe for cider)	*Pyrus nivalis*
Quince	*Cydonia oblonga*
Peach	*Prunus persica*
Nectarine	*Prunus persica* var *nucipersica*
Apricot	*Prunus armeniaca*
European Plums	
a. The common plum such as Green Gage and Italian prune	*Prunus domestica*
b. The Damsons and others	*Prunus insititia*
American Plums	
a. Found from Maine to Florida and east of Rocky Mountains from Mexico to Canada.	*Prunus Americana*
b. Especially suited to southern states but also grown in North.	*Prunus hortulana*
c. Especially suited to colder regions.	*Prunus nigra*
d. Important in South	*Prunus munsoniana*
Japanese Plum	*Prunus salicina*
The Sour Cherry	*Prunus cerasus*
The Sweet Cherry	*Prunus avium*

Common Name	Scientific Name
The Duke Cherry	*Prunus cerasus*, crossed with *Prunus avium*
The Southern Grape (muscadine)	*Vitis rotundifolia*
The Eastern Grape	*Vitis labrusca* or *Labrusca crosses*
Old World Grape (grown on the Pacific slope)	*Vitris vinifera*
European Red Raspberry	*Rubus idaeus*
American Red Raspberry	*Rubus strigosus*
Black Raspberry	*Rubus occidentalis*
Purple Raspberry	*Rubus neglectus* (hybrid red and black raspberries)
American Blackberry	*Rubus argutus*, *Rubus allegheniensis* and other species
Dewberry	
a. From Maine westward and southward	*Rubus flagellaris*, and *Rubus invisus*
b. Southern Dewberry	*Rubus trivialis*
c. Western Dewberry	*Rubus vitifolius*
Red Currants	
a. Common Red or garden Currant	*Ribes sativum*
b. Northern Red Currant	*Ribes rubrum*
Black Currant	*Ribes nigrum*
American Gooseberry	*Ribes hirtellum*
European Gooseberry	*Ribes grossularia*
Strawberry	*Fragaria chiloensis virginiana*
High Blueberry	*Vaccinium corymbosum*
Low Blueberry	*Vaccinium pennsylvanicum*
Large Cranberry	*Vaccinium macrocarpon*
Small Cranberry	*Vaccinium oxycoccus*

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