FIELD MANUAL

for

SUGAR BEET GROWERS

A Practical Handbook for Agriculturists, Field Men and Growers

BY

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PREFACE.

The most important improvement in sugar beet growing will come in the bettering of growing methods so that the acreage returns will be increased. The average yields are below what they should be with proper attention given to the demands of the plant. When the beet receives the benefit of proper environment the acreage returns for the beet growing sections will be greatly increased—50 to 75 per cent in many cases.

In this work the author has aimed to develop the subjects which are closely connected with the growing of the sugar beet in the field. It is taken for granted that the farmer understands the general principles of farming and the author's aim is simply to show the relationship of those principles to the growing of sugar beets. This "Manual" is gotten up to record the results of practical experiments and comparative field observations for the good of those interested in the beet sugar industry. The pages contain information which the author has had to collect from various sources—laboratory, field and library—for use in his work in growing the sugar beet. He believes this information will make interesting and profitable reading to all who have to raise the beet or who have the good of the agricultural side of the beet sugar industry at heart. Many of the factors which enter into the successful raising of the crop are taken up. These may be of interest to the more or less advanced farmer as the aim has been to elucidate the principles upon which successful beet culture is based, and which, in the majority of cases, are not thoroughly understood.

At this point the author wishes to give credit to the writers of the various books and articles upon which he has drawn in gathering this data. While in the main this book records his own observations and experiments, he has found occasion to consult other sources, the number being so numerous that it is impossible to cite all to whom he is indebted. The *Orange Judd Farmer,* the different state experiment stations, the United States Department of Agriculture and THE AMERICAN SUGAR INDUSTRY deserve special mention. Liberal extracts of several articles of the author published in the *Orange Judd Farmer* are utilized in this text.

The author is also deeply indebted to Mr. L. Myers for his kindness in writing out at length the article on "The Growing of Sugar Beets in the Salt River Valley—Arizona," which appears in the text. R. L. ADAMS.

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INTRODUCTION.

To develop the beet to the best advantage the necessary conditions are a rich, fertile soil, proper distribution of rainfall or irrigation to start and maintain the crop with a lessening towards harvest, warm, sunny weather to aid maturing, freedom from sudden, severe changes of weather and fair weather for harvesting. When these conditions exist in tracts of considerable area, in connection with proper limerock, transportation facilities and plenty of good water and fuel, a sugar mill is as good as established, for it will come in time. Only favorable natural conditions will bring about the investment of such sums of money as the establishment of a sugar mill involves. When a sugar mill is put up, that alone is sufficient evidence that the section is adapted to the culture of the sugar beet and the grower need take no further concern regarding the general adaptability of the country. His duty will consist in determining the possibilities of his own farm for beets. If conditions are such that he can grow them he is fortunate, for it means increased wealth to him and a marked improvement in his soil.

The distance from a sugar factory will largely determine the growing of beets, as their profitableness depends very greatly on the distance of the haul. Often by utilizing the railroad, beets can be raised at a good profit, where otherwise the wagon route would prove to be too long a haul. On the other hand, the attractive reductions in freight rates on beets offered by the majority of railroads make beet growing at quite a distance from the mill profitable. Shipments of beets from seventy-five to one hundred miles or more are by no means uncommon. Each farmer must decide for himself the possibility of successfully marketing his beets after they are grown.

Amount of Capital.—Beet raising on a large scale requires special tools and considerable of an investment to carry the crop through. If a responsible man does not have the means himself or a way of getting it he will find that most sugar mills are ready to back him, either by making him loans direct or by endorsing him at the local banks. In fact the local banks can be counted on for financial backing to a great extent.

Beet raising on a small scale can be carried out with but little change from the usual equipment of the ranch or farm. In putting in beets it is well for a man new to the business to go rather slow. Better put in a few acres and, experimenting with these, gradually increase the acreage, than to put in too much at first and make a partial failure of it. This would result in such disappointment that the grower would fail to give the beets another conscientious trial. The ultimate aim, however, should be to run to beets as far as consistent with the handling of the farm.

Before changing from ordinary field crops to beets on a large scale the farmer should consult freely with the factory authorities as to the extent of the investment required and the nature of the tools to be purchased, should he be at all unfamiliar with the different aspects of beet culture. Both the mill agriculturist and the superintendent will be only too willing to lend all the assistance in their power. They desire a large supply of beets and will, therefore, be only too glad to give the prospective grower all the information they can.

The Value of a Contract Price.—To know what one is to receive for his crop when harvested is a great advantage. This is one of the advantages attendant on beet culture, as the price at which the crop is to be sold is stipulated previous even to sowing the seed. This benefit will be especially appreciated at harvest time in dull seasons. Then the sight of potatoes piled under straw in the fields, grain in stacks and huge piles of hay under board covers will testify in a mute but vigorous manner to unforeseen low prices. And until these crops are moved there will be little money for those to come.

So, aside from the fact that there is little satisfaction in raising a crop and having it left on hand, there is the dissatisfaction of planting the same crops again with the almost certain possibility of a stagnant market when they come in.

Profits on Sugar Beets.—The final test of the value of any crop is the maximum financial returns for the minimum drain on soil fertility. The aim of every thinking farmer is to prolong the life of his land indefinitely, and at the same time receive the greatest acreage returns. He builds not alone for the present but for the future, and the scheme of growing which brings in the greatest returns for a period of years will be the one he selects. In this connection the value of the sugar beet has been proved time and again. It benefits the soil because of its deep rooting habits. If used in rotation this is especially noticeable. The deep feeders of the beet secure plant foods from the layers of soil deep down in the ground, where the shallow roots of ordinary crops can never go, and deposits them as salts in the crown of the beet just at the base of the leaves. This crown is cut off when the beet is topped and left on the ground, where in rotting it liberates phosphoric acid, potash and nitrogen in a form ready for the next crop. The big bulk of tops, if turned under green, will furnish an abundance of humus—one of the most important ingredients of fertile soils.

But aside from the benefit to the land—and in addition to the one just stated are others which will be considered further on—is the income. This furnishes a bright financial picture. It is true the cost of producing the beets is greater than of many other crops, but the returns are proportionately greater. This can be quickly proved by any farmer who goes to the trouble to keep track of all the work done on his various crops. Correct figures are convincing. The data given here has been worked up from the carefully kept records of independent beet growers. They are, therefore, well worthy of consideration. These figures will not hold for every section because of the varying productivity of different classes of land, and the different costs of carrying on the work. The returns and prices of the crops compared, however, err on the side of high yields and high prices so that of all the crops the beet crop has whatever disadvantage may exist. Beet yields of fifteen tons are common, many ranches producing an average of twenty tons, and a few as high as twenty-five. With only ordinary success every ranch fairly well adapted to beets should produce fifteen tons.

In the beet table the results of two fields are given, the first consisting of 650 acres and the second of 324. Each represents a different type of soil. The first is a splendid loam, the second a sandy loam. The first was near the mill, the second 28 miles away, 25 by railroad and 3 miles by team.

If the work be done by the farmer himself, he is paid for his time in this estimate, so in reality the returns are higher than shown in the estimate, as he makes on his crop and on his services.

TABLE SHOWING THE COST OF RAISING AND MARKETING BEETS PER ACRE.

	No. 1.	No. 2.
Irrigating	$ 3.68	$ 1.10
Plowing	4.20(a)	1.54(b)
Harrowing, rolling and dragging	3.35	1.58
Cultivating	1.52	.76
Sowing and seed	2.49	2.10
Thinning, hoeing, weeding, topping and loading	18.62	16.83
Poisoning and trapping gophers	.04	....
Sundries	.09	....
Plowing out and hauling	7.64	8.26
Loading on cars	.54	3.00
Freight	5.05	7.82
Cost per acre	47.22	43.90
Yield per acre—tons	19.0	15.3
Value per acre	$95.00	$76.50
Profit per acre	47.78	32.60
Cost per ton	2.48	2.87
Value per ton	5.00	5.00
Profit per ton	2.52	2.13

(a) Steam plowed sixteen inches deep.

(b) Horse plowed ten inches.

Barley has always been considered a good crop, but the returns are more apparent than real. It is the lazy man's crop. The crop is a cheaper one to produce and the profits per acre are correspondingly less. Good bottom land will produce on an average twenty sacks per acre, costing as follows:

TABLE SHOWING THE COST OF RAISING AND MARKETING BARLEY PER ACRE.

One plowing	$ 1.00
Sowing and harrowing	.40
Ring rolling	.25
Seed	1.00
Heading	1.30
Threshing	1.80
Sacks	1.40
	$ 7.15
Value of 20 sacks (100 pounds each) at $1.00	$20.00
Less cost	7.15
	$ 12.85

This is about one-third the profit on beets.

Beans will produce a crop of 1,200 pounds worth, at 3 cents a pound, $36 to the acre, gross. The same land will raise twenty tons or more of beets to the acre. The cost of growing the crop is:

Two plowings	$ 2.50
Three harrowings	.60
Ringrolling	.20
Planting	.25
Seed	.60
Harvesting	3.00
Cutting vines	.50
Sacks	1.00
	$ 8.65
Value of crop	$36.00
Cost	8.65
	$27.35

Potatoes are a good crop, yet they do not rank above beets.

TABLE SHOWING THE COST OF RAISING AND MARKETING POTATOES PER ACRE.

First plowing	$ 1.00
Second plowing	1.50
Harrowing	.20
Planting	.50
Seed	2.75
One cultivating	.40
Harvesting	12.50
Sacks	2.80
	$21.65
Value of crop, 40 sacks (100 pounds each) at $1.40	$44.00
Seconds	2.75
Thirds	.50
Total value	$47.25
Cost	21.65
Profit	$25.60

Peas do well in a year of good rainfall, yet the profit is small.

TABLE SHOWING THE COST OF RAISING AND MARKETING PEAS PER ACRE.

Plowing	$ 1.00
Harrowing	.20
Cultivating	.40
Ringrolling	.25
Seed	.50
Harvesting	3.00
Sacks	1.00
	$ 6.35

The value is very liable to fluctuate for brokers have a failing for speculating with it. If the price is two cents a pound, the value of a 1,200 lb. crop

will be	$24.00
Less cost	6.35
Leaves a profit of	$17.65

In all these estimates good land and good quotations for prices are used in order to make as fair an estimate as possible. That these results are higher than usual is evident from a glance at the United States Department of Agriculture census. Here the average acreage crops for the last ten years are:

	Yield	Price	Farm Value Per Acre
Corn, bus	25.2	$ .371	$ 9.35
Wheat, bus	13.5	.694	9.37
Oats, bus	29.6	.281	8.32
Barley, bus	25.1	.412	10.34
Rye, bus	15.4	.525	8.08
Buckwheat, bus	18.1	.535	9.68
Potatoes	84.4	.499	42.12
Hay, tons	1.44	8.070	11.62

Sugar beets are not included in these figures, but it is only fair to state that the average for the whole United States is 9.71 tons. Still at $5 per ton for the beets, they would stand at the head of the "farm value per acre." But the average for the beets is lower than the usual grower can afford to be satisfied with. It takes the first six to eight tons produced to pay the cost of raising the crop and marketing it. The profit must come from the tonnage in excess of this.

Summing up the examples given above shows:

Crop.	Value.	Cost.	Profit.	Increased Profit from Beets.
Beets	$85.00	$45.56	$39.44	.....
Grain	20.00	7.15	12.85	$26.59
Beans	36.00	8.65	27.35	12.09
Potatoes	47.25	21.65	25.60	13.84
Peas	24.00	6.35	17.65	21.79

And these figures presuppose the continuation of high prices. If these should fall or if long storage must be resorted to, the benefits of a prearranged price and direct shipment from field to factory will stand out very prominently. On the other hand, the price paid for the crops listed, other than beets, must make big advances in prices received to even equal the profits from an average beet crop, to say nothing of the unheard of advance necessary to surpass them.

Moreover, while the yields from a single acre stand out so markedly, multiply the results by the yield of 100 acres. The gain, then, of beets over other crops is from $1,209 to $2,659, while the ranch is left in better shape than ever for future maximum production.

Soils for Sugar Beets.—Desirable soils for sugar beets vary in both physical and chemical composition, but all must be fertile, deep, moisture-retaining soils of loam or clayey loam containing enough sand or silt so that they can be easily worked.

Physical Nature.—This applies to the shape and size of the soil grains, and the formation of the land both in depth and area. Land made up of very fine grains will prove to be too "cold" and heavy to work. Adobes are in this class. When the soil grains are too large the land will not hold moisture. Sands are examples. The land which is best adapted to beets is fairly level, deep, free from stones, loose sand and black alkali; not too fine in texture on one hand, nor too coarse on the other. Land, which will produce good corn, wheat, potatoes or beans will grow beets if it has good depth. The best land on the farm should always be selected for the beets.

New brush and timber soils will not produce good beets at first, as being very rich they produce beets low in sugar and purity because of the great amount of soluble substances present in the soil, which the beet will absorb in feeding. This effect will wear off in a couple of years. If desired, corn, potatoes or other crops can be put in to advantage for the first season or two.

The depth of the soil is important as the beets make a deep growth and need plenty of room in which to develop. There should be no impervious layer of soil above a 4-foot depth. Even a greater depth is desirable. The character of the land in this respect can be determined easily with a shovel, a post hole digger or with a soil augur.

The soil should be of the same general nature so that movement of soil moisture will be fairly uniform. No extensive layers of sand or gravel should intervene to the depth to which the plant is to feed and secure its water. Further down they may be beneficial for drainage purposes if of no great extent. They would prove especially valuable in using alkali water, as will be discussed later on.

In short, at least 4 feet of fairly uniform soil is necessary. Where ample spring and early summer rainfall occurs $2\frac{1}{2}$ feet will do, but in arid or semi-arid sections 4 feet is the extreme limit.

The water table must in no case stand nearer the surface than 4 feet. If it does, rotting of the tap root of the beet will result. Best yields, then, can in no case be expected.

Plenty of humus is required. It makes the soil easier to work, more retentive of moisture, less liable to bake, crack and crust, and is richer in plant foods.

Stiff adobe or gumbo, and very stiff clays should be avoided. These are very difficult to work and must be caught at just the proper stage of moisture to insure germination before the soil dries out. Moreover, unexpected rains following planting will work havoc by crusting and packing the soil, and by inducing root rot on the seedlings. Soils approaching adobes are being worked to advantage in many parts of the country and great crops have been taken off of strict adobes but the chances for failure on the very heavy soils are greater than for success, and it is better to leave such soils alone. The best land is none too good for beets and on such soil they will do their best and be a source of profit to the farmer. A clayey loam, rich in humus, is to be preferred. Such soils are a trifle harder to work than the lighter soils, they must be handled within shorter limits of time and moisture and the seeders give more trouble in this class of soil. But the final returns are greater, and as results are what count, it is well worth the extra effort put forth. Moreover, these soils hold their moisture better, as a rule are richer in plant food, and will withstand greater demands from the crop.

While the above may be the best type of soil to use, it usually happens that soils vary from one extreme to the other. It is usually necessary for the farmer to make the best of what he has and to work out the questions of handling, time of planting, and variety of beet to suit his needs, whether the beet be a main crop or a rotator. For the greatest benefit to both grower and factory the land producing the greatest tonnage of fair-testing beets will prove the most desirable in the long run rather than land of less tonnage-producing power but greater sugar-forming ability.

Chemical Nature.—It is extremely difficult, in fact impossible, to obtain a table of chemical analyses which will apply to all beet soils. All agricultural chemists are aware of the presence of other influences aside from the amount of chemical elements present. The physical condition of the soil, the form in which the essential elements are present, and the amount of available moisture play such an important part and are so correlated with the chemical factor that all must be considered in judging the land. While a chemical analysis is not a sure guide in all cases, still, for purposes of reference the following table of analyses of profitable sugar beet soils is interesting:

TABLE SHOWING ANALYSES OF SUGAR BEET SOILS.

	Humid sections. Per cent.	Arid sections. Per cent
Insoluble matter	84.03	70.57
Soluble silica	4.21	7.27
Potash	.22	.73
Soda	.09	.26
Lime	.11	1.36
Magnesia	.23	1.41
Manganese	.13	.06
Iron	3.13	3.75
Alumina	4.30	7.89
Sulphuric acid	.05	.04
Phosphoric acid	.11	.12
Carbonic acid	..	1.32
Water and organic matter	3.64	4.95
Humus	2.70	.75
Nitrogen in humus	5.45	15.87
Nitrogen in soil	.12	.10
Hydroscopic water	*4.65	6.28**

But even in this table the limits of fertility cannot be taken as complete guides, because it is not the total amount of each element present, but its availability, which counts. In illustration of this point the availability of the phosphoric acid depends on the lime content; if the lime is low the phosphoric acid is only slowly available. This holds especially true with respect to arid regions for where the lime content is very high usually much less phosphoric acid is required.

The actual test of growing beets with a series of fertilizer tests will prove the surest way of determining the lack of any plant food.

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*At 18.5 degrees Centigrade. **At 15 degrees Centigrade.

Alkali.—Alkali is a problem entirely confined to arid or semi-arid regions, and is simply the accumulation in the soil of those salts which form in the progressive weathering of the rock grains comprising the soil. In all parts of the country the soil particles are constantly breaking down and liberating the salts contained in them.

From the standpoint of plant growth these salts are of two kinds, one beneficial and needed for plant development, the other of negative or even injurious character. The first will be retained in the soil to a great extent, the second is very soluble in water and in region of sufficient rainfall will be taken into solution and pass into the springs and brooks, and through these to the ocean. But when the rainfall is light the salts are left in the soil, and year by year, will accumulate until the total amount present will be so great that ordinary plant growth is impossible. The abundant rainfall of the eastern sections accounts for the absence of alkali. There the rainfall is sufficient to leach out the soluble alkali salts as fast as they are formed. But certain plant foods also are soluble and these will be lost along with the alkali, so that while the injurious salts are retained in arid sections because of insufficient rains to wash them out, at the same time the soluble plant foods are retained. This explains the great richness of the arid section when brought under cultivation by means of irrigation, for along with the accumulation of alkali salts are plant foods which have been liberated and stored for the future.

Alkali soils differ from soils containing salts laid down in old sea formations, or from soils treated to an occasional overflow from the sea. In cases of this kind there is little present that the plant can use, for common salt, Epsom salts, and the like predominate, and these are of an injurious nature and are far in excess of the plant foods.

In order to determine the nature and extent of alkali soils and their agricultural possibilities, a chemical analysis is necessary. Such analyses when based on samples secured by a systematic sampling of the field in question to different depths and at different points show the extent and nature of the salts. It will prove a far quicker and more reliable guide then the trial of growing crops. For not only will the tests show conditions as they exist, but the remedy usually will suggest itself from a study of the land when sampling and from the results of the analyses. For instance, if the salts are coming from beds deep down in the soil through the action of water, the analysis will be the surest way of finding it out. In connection with the chemical work must come a study of the soil formation, the general topography of the country and the irrigation water. A little study of the conditions which are bringing, or have brought about an excess of alkali, usually will show the methods that must be adopted to offset them.

Alkali salts generally are of three kinds, common salt (sodium chloride), Glauber's salt (sodium sulphate), and salsoda (sodium carbonate). The first two are the so-called "white alkalies," named from the white incrustations which they produce on the surface of the ground. The salsoda is popularly known as "black alkali" because of the black spots or puddles which show where an excess of the alkali exists. In addition to these, magnesium sulphate, calcium chloride, and magnesium chloride may be present in sufficient quantities to prove injurious.

With the alkali salts are associated the three elements of plant foods, potassium, phosphoric acid, and nitrogen. These usually are present in the proportion of:

Potassium, 5 to 20 per cent of the total salts.
Phosphoric acid, .5 to 4 per cent of the total salts.
Nitrogen, .1 to 20 per cent of the total salts.

In white alkali the nitrogen is high and the phosphoric acid low; in the black alkali the reverse is true.

Alkali salts do not remain stationary in the soil. They move up and down in the soil layers according to the moisture conditions. Hence, at different periods the maximum amount of salts will be at different points. Following heavy winter rains or applications of irrigation water the salts are dissolved in the water and carried down with it into the lower levels of the ground. When the water begins to reascend and evaporate the salts are carried up to the surface, or to the point where evaporation is going on and redeposited. If, though, the water passes into gravel layers or into streams the salts will be carried with it away from the land. Where this condition occurs naturally, there is never alkali accumulations.

The presence of alkali salts comes about in two ways on land which is being farmed, (a) in the water reaching the land either as irrigation, seepage or underground flow, or (b) from deposits of salts in the soil which are brought up from below by the movement of the soil moisture. In the latter case the salts can only move by their own power to a height of about three to six feet (depending on the character of the soil). In order to rise from a greater depth, whether they be in the water table or deposited in beds, communication with the surface can only be brought about through several successive periods of depositing and going into solution, the amount of water being so regulated that it does not carry the salts back to their original depth each time. The deeper the salts are buried the smaller chance do they have to reach the surface. Alkali below ten feet where ample irrigation is given without swamping the land will successfully guard against this.

A study of the extent of alkali shows that the quantity of salts varies in different parts of the same field. Low depressions where the rainfall gathers will cause much more alkali to come to the surface than where there is a less amount of water. In sloping valleys it occasionally happens that the salts from the adjacent hills are deposited to such an extent that broad stretches of alkali running to considerable depth will form, but these are extreme cases and of infrequent occurrence. Often alkali hard-pans will form in the soil at the depth to which the normal rainfall sinks, and will prove almost impervious when first brought into cultivation. These, however, if of limited extent, will finally give way to the effects of repeated irrigations. The seepage of irrigation waters, charged with alkali salts, from a higher to a lower level has worked havoc in the case of over-irrigation.

Only a study of local conditions will point out the solution. The problem may be only to dispose of the salts present in new land which is to be put in shape for crops. Or the accumulation may be the result of cultivation, such as over-irrigation, by which salts deep down in the soil are brought into the upper levels; or it may be caused by too large a percentage of salts in the irrigation water, from seepage, or from some other local condition. Often the question involves a district rather than a locality. When such is the case only methods aiming to remove the cause will prove of permanent value. Such a case requires deep study, much scientific work, and is entirely outside the scope of the average beet grower.

The first duty then in dealing with an alkali problem is to determine its extent, whether local or general. If local, each grower can, in many cases, work out the solution for himself.

Since the salts rise in the soil with the evaporation of the soil moisture any method which will lessen evaporation will lessen the rise of the alkali. When a given amount of alkali is distributed throughout three or four feet of soil it will not prove detrimental, whereas the same amount brought up by evaporation of the moisture and deposited in the first three or four inches of soil will concentrate to such an extent as to interfere seriously with the plant's activities, and possibly cause them to cease altogether.

The quick growing of the plants to shade the ground and the maintenance of a loose mulch by deep cultivation will do much to retard the concentration of the salts. Deep preparation of the soil and thorough surface cultivation are the most important factors for securing results on alkali land.

When black alkali is present it is possible to change it over into the sulphate form (Glauber's salt—a white alkali) by the use of gypsum (land plaster, or calcium sulphate) if there is ample moisture in the soil. That the Glauber's salt is less injurious than the black alkali can be seen in the resistance of barley. This crop can stand five times as much of the white alkali, Glauber's salts, as it can of black alkali. The amount of gypsum to be used will depend on the amount of black alkali present. As a general rule, one ton of the ordinary gypsum will be required to neutralize 1,000 pounds of black alkali. All need not be put on at one application. Enough to neutralize the surface soil can be put on at first, adding more later on until the desired total amount has been added to the soil.

Moisture must be present to change the black alkali into white. Chemically this is a conversion of sodium carbonate and calcium sulphate into sodium sulphate and calcium carbonate, (common lime stone). It takes a few days for the action to be completed in very wet soils. In soils with lesser moisture the change will be proportionately slower. Where the black alkali is present in spots the use of gypsum will give marked returns. The hard, puddled condition will crumble into a loose mass thus permitting good drainage, and humus will be once more returned to the soil. To be permanently beneficial the danger of swamping the land with an excess of water must be constantly guarded against. The black alkali is the only kind open to this method of treatment.

The removal of salts can be accomplished by scraping off a few inches of the top soil at a time when the majority of the salts are deposited there, that is, at the driest time of the year. In this way often one-half of the total salts present in the soil can be removed in one season.

Removal by thorough irrigation is feasible when the under-drainage is good. The water will take up the salts and carry them on down into the under-drainage of the country far out of reach. To make this method entirely successful ample water must be available, so that the soil, previously checked for even irrigation, can be given a thorough soaking. With this must be good drainage, either artificial or natural. Subsequent careful irrigation, constantly bearing in mind the danger of swamping the land, will effectually keep the salts down indefinitely. even if they should not be taken up by underground flows. This means that in lands where the water table is so deep that it is not feasible to reach it with the irrigation, it is possible to so thoroughly soak the land that the salts, with future ordinary precautions, can be kept deep down in the soil, out of reach of the surface. Where danger of excess water exists, on the other hand, under-drains must supplement the work of irrigation.

Flushing the land with water with the object of taking off the salts, by means of a big rush of water across the ground is not successful, as the first water is bound to go rather slowly and sink into the ground to a certain extent. This carries the salts down into the soil beyond reach of the swifter water which follows.

The plowing under of stable manure and the use of potash salts are generally of little value in ridding land of alkali.

The amount of alkali which can be resisted by the sugar beet varies with the kind of soil. In sandy soil its tolerance is much higher than in clay lands, because in the latter the alkali exerts an injurious effect on the tilling qualities of the soil, and moreover, evaporation is so much greater that the depositing of salts at the surface, with their attendant increased corroding effect, is much enhanced. This applies to all farm crops as well.

Beets grown in soil impregnated with common salt, sodium chloride, are wholly unfit for sugar purposes. However, after being grown for several years on salty land they will so reduce the salt content that eventually really good beets can be grown. Beets grown on land heavily charged with Glauber's salt are, on the other hand, well fitted for sugar purposes, good yields of high grade beets being obtained regularly from land containing as high as 12,000 pounds of this salt per acre.

The actual percentages of each of the salts when alone which the sugar beet can withstand and still make a satisfactory growth has been found to be, in the first three feet of soil (in depth):

	Pounds.
Sulphates (i. e., Glauber's salt)	70,000
Carbonates (i. e., black alkali)	4,000
Chlorides (i. e., common salt)	4,500

As to the amount when two or more are present, the proportions can vary in an infinite variety of ways, so that a general rule is all that can be satisfactorily given. It is certain, however, that of the chlorides and sulphates (common and Glauber's salts) the chlorides are by far the most injurious, .2 of 1 per cent is a dangerous limit, while .15 of 1 per cent is apt to yield uncertain crops. In other words while the total amount of common and Glauber's salts may equal one per cent, not over .2 per cent must be common salt.

With black alkali a very much less amount is injurious than with either of the other two. The following table shows the limits of resistance for all plants, if all the salts are concentrated in the first foot of soil:

Black alkali, .1 of 1 per cent, or 4,000 pounds.
Common salt, .25 of 1 per cent, or 10,000 pounds.
Glauber's salt, .5 of 1 per cent, or 20,000 pounds.

It should be clearly understood that the amounts given in the preceding paragraphs are but general guides. A less amount may prove injurious if kept constantly concentrated, and a greater amount can be withstood if it remains scattered throughout a great depth of soil at all times. During one period of the year a definite amount of salt will be injurious when at other times it is harmless. Beets have done well in soils containing greater amounts, while on the other hand a smaller amount has been sufficient to work havoc with other soils. This difference often can be traced to the intelligence of the men doing the farming, as the effect of the salts largely can be regulated by the farming methods. In addition to this, local climatic conditions, the soil formation and the source of the alkali salts all have an influence.

In the case of the sugar beet the greatest danger from alkali lies in the danger of retarding germination by corrosion or erosion, or in the actual destroying of the young seedling after it starts. When once established the sugar beet is immune to alkali. In fact it is one of the crops usually recommended by writers on alkali for growing on soils heavily charged. Coming in early times from the banks of the Mediterranean, the beet still retains its resistant nature to alkali action, in spite of the decades of civilization through which it has passed.

In the majority of cases the danger to germination and young seedling is slight if the beets are put into deep, well prepared soil at a time when the bulk of the alkali is well distributed through the layers of soil, either from the preparatory irrigation or from the rainfall. By the time a new accumulation of salts has occurred the beet will have reached a state of immunity. By their quick growth the leaves soon cover the ground and in shading it reduces surface evaporation to a minimum. The roots take the moisture from deep down in the soil and evaporate it through the leaves, so that in this way the salts are held deep down in the soil, Moreover, the beet takes up large quantities of salts in feeding, which are bodily removed from the soil in harvesting the crop. So in many ways the beet prepares the soil for the better reception of such other crops as are to follow. It keeps the salts so deep down in the ground that the following winter rains or irrigation can carry them still deeper, and it removes large quantities bodily from the soil. In this way the land is better fitted for the subsequent planting of crops more sensitive to alkali.

In disturbing plant growth alkali works in two ways. The first is the corrosive action at the surface of the ground, already spoken of, which results in a brownish tinge showing on the stalk or stem of the plant, while the outer epidermis (bark) becomes soft and easy to peel. The alkali in this case actually girdles the plant. While it may not die, future growth usually is slow and unprofitable. Black alkali acts worse by far in this respect, and also burns out the humus to such an extent that such lands are difficult to work and develop tough, impenetrable hard-pans, which seriously interfere with drainage.

The second method of poisoning comes from a disturbance of the activities of the feeding roots. Plants gain all their food by taking up the soil moisture containing them in solution through the walls of the tiny, threadlike hair-roots. There are no openings. The plant has no power of selection and must take up everything that is in solution. The passing of the salt-charged moisture from the soil into the root depends on the difference in density between the moisture outside and the sap inside the rootlets. It is greater in the root. When the density on the outside approaches that on the inside, passage of the water into the root is checked, and the plant starves.

Where alkali is giving trouble a study of the problem will reveal the cause. With a little knowledge of what constitutes the source of the trouble, methods for prevention can be undertaken based on the character, extent and nature of the salts, and on their source. Alkali lands are very rich in all plant foods and possess good moisture-retaining powers so that when the total quantity of soluble alkali is reduced to a point where it is no longer injurious great crops can be raised. For this reason money spent on reclaiming alkali lands or in checking increasing accumulations of salts will be money well spent, provided the initial cost is not too great.

In Europe several investigators hold that the sugar beet will actually respond to a light dressing of salt. The salt seemingly has the power to interchange bases with the potash salts in the soil, thus making the potash more available. For soils rich in unavailable potash, the use of small quantities of salt (150 pounds per acre) has been suggested. The water drawing and retaining power of the salt has been cited as a possible valuable asset on light, sandy soils.

CHAPTER I.

Cultural Work.

In taking up the cultural work of the sugar beet it is assumed that the grower will avail himself of the services and experiences of the factory field superintendent. Local conditions to a large extent determine the best methods to follow in order to reap the maximum results, or in other words, the biggest crops. Guided by personal efforts, and coming constantly in contact with the experience of others, the mill agriculturist can advise to good advantage. The interests of the grower and the superintendent are one—the biggest yield for the acreage—and both should endeavor to work in perfect accord. Questions as to the best time to plant, the best method of handling the labor problem, the variety of seed to plant and the time of harvesting must be determined largely by local conditions.

Plowing.—The depth and time of plowing will depend on whether the land is new and going into beets for the first time or whether it is old cultivated ground.

Fall plowing is to be recommended in either case. By fall plowing alone, I have increased the yield of sugar beets 44 per cent. The reason for this is to be explained in the better mechanical condition, for in its openness the soil will absorb all the winter rainfall, and through aeration the soil permits the natural agencies (fungi, bacteria, etc.) to work to the best advantage.

New land should not be plowed very deep. Seven or eight inches is enough. Neither should land which has never been deeply plowed be turned up to the final depth at once. Better to run the plow furrow only an inch or two deeper than the old depth at first, gradually increasing this at each subsequent plowing until the final depth is reached. This does away with the danger of bringing a lot of raw soil to the surface of the ground, thereby decreasing crop yields for the time being. The final depth should be as far down as it is possible to work the land. Many sugar companies who are farming their own land go regularly to a depth of 24 inches by the use of power engines. The man depending on horses should have sufficient stock to plow twelve inches deep, and implements heavy enough to stand the strain.

Alfalfa land which is to be prepared for beets should be plowed in the fall very shallow, not to exceed 3 or 4 inches deep, the aim being to cut off the old alfalfa plants just below the crown. The plowing is followed with a spring tooth or spike harrow to bring the crowns to the top of the ground, where any sprouting will be killed by the sun and wind. Alfalfa must be given proper attention or it will regain its hold and tend to choke out the beets during the succeeding year. If the land is plowed deep the crowns will be turned under. They will then remain alive and start to grow again in the spring. When the crowns are thoroughly dry, the land can be plowed more deeply.

In new land any leveling that is necessary should be done before the plowing. With alfalfa land it should follow the first plowing and precede the second. Moreover, when winter or previous irrigations are given they should precede this plowing, in order to give the weeds a chance to grow. The bulk of them will then be disposed of by the plowing.

Grain land should be disked or ringrolled before plowing in order to break down the stubble and even the surface of the land.

For all land which has been handled for beets, or other crops demanding a deep preparation of the soil, there may be a deviation from the above. The land should then be plowed to the required depth as soon as it is dry enough after the irrigation or wet enough from the natural rainfall to put it into condition. When the soil will fall away from the mouldboard of the plow without sticking, and still retains sufficient moisture so that it can be molded in the hand it is safe to work it. By this time the weeds will have started. Following the plowing the land should be lightly harrowed. If the ground is rough from harvesting a beet crop the year before, from stubble, or from any cause a ringrolling or a slabbing before the plowing will greatly assist.

Throughout the winter the land may lay idle with only occasional treatment of the weeder or cultivator, should the weeds get a bad start.

For putting the land into shape in the spring, the handling of both new and old land is essentially the same.

Putting the Land Into Shape.—Early in the spring the land may be given another plowing, shallow this time, 3 or 4 inches deep. This will not be needed unless winter rains have interfered with the use of the weeder so that the weeds have a good start. If the weeds have been held in control the land can be cultivated down and the plowing omitted. If the land has not been packed by the winter rains and snows it is necessary to do this with the farm tools. The aim should be to cultivate to the depth of plowing in order thoroughly to firm the land from surface to depth of plowing. When the land is naturally well settled the deep cultivation may be dispensed with and only a shallow one given. Following the cultivator, will come the harrow, drag, ringroller or roller, the kind of implement and the order and amount of work each must do depending on the nature and condition of the land.

During the spring work any plowing or deep cultivation must be worked down immediately, so that by nightfall no rough land is left. In other words stop plowing or cultivating early enough to run the implements for fining the surface soil before the day's work is considered complete.

Under no conditions should the land be handled too wet as the danger of packing the land too solid is great. Should this occur and no rains follow, the decreased crop will be a striking lesson. As the rains may fail and as irrigation is expensive, where available, it is better to avoid all risk in the first place. As stated before, when the soil will crumble away from the mouldboard of the plow, and not ball up on the cultivator and harrow teeth, still retaining enough moisture to hold together, or when the soil can be molded in the hand and still crumbles on pressing, showing no sign of excess moisture, it is in the best possible condition for working and can be handled to the best advantage.

By keeping the land constantly worked down dependence need not be placed on late rains. It is much better policy to hold the moisture until time for planting by an occasional harrowing or dragging, than to leave the land rough until the last moment.

The final operation should be a harrowing. Leaving the land dragged tends to make it crust if a rain comes, and also causes too excessive evaporation from the soil. But if moisture is needed for the sowing, a dragging just before planting will cause the rapid movement of soil moisture to the surface. For this purpose dragging is good.

Once the land is in shape it should lay for a week or ten days to settle and to enable the moisture conditions to equalize throughout before being seeded.

Adobe or gumbo soils should be given as little working as possible in the spring, and not opened up at all. Seeding should be done a day or so after the land is ready, and every effort made to get the land into shape and planted at the earliest opportunity. Once such soils dry out, re-establishment of the moisture is almost impossible unless they receive more water.

The whole idea in preparing the land is to secure a well-fined, well-packed, well-stirred seed bed, and any method which will bring about this condition will be well repaid in the better growth of the beet.

Subsoiling is not practiced on old soils as much as formerly and, where no plowpan or hard subsoil exists near the surface, is hardly necessary. After a crop of beets has been raised the deep plowing out at harvest time is practically a subsoiling.

However, where shallow plowing has been the rule and beets are to be put in for the first time, it is well to follow the plowing with a good, deep subsoiling or cultivation to the depth needed for the beet's development as the plowing must go but little deeper than formerly at first.

Seeding.—As the future of the crop depends to a great extent upon the stand secured, too much care cannot be exercised in the matter of seeding. At least 14 pounds of seed should be used to the acre, and even more if the land is not in the very best condition for sowing. Most farmers use too little seed and the result shows in the final stand. Heavy seeding gives extra plants for insect and fungus depredations and while it entails a slightly increased expense, will, at thinning time, permit the selection of robust specimens.

That the greatest stress must be laid on the stand for the final returns is shown in the following example:

A square acre is approximately 209 feet on a side. If the rows of beets are twenty inches apart there will be 125 rows. If the beets are thinned to ten inches apart, and at harvest weigh 38 ounces the yields according to the stand will be:

Percent of Perfect Stand.	Number of Beets	Yield Per Acre Tons.
100	31,350	39.19
99	31,036	38.80
98	30,723	38.41
90	28,215	35.27
80	25,080	31.35
60	18,810	23.51

As the average stand which looks good comprises but 80 per cent of a perfect stand in the majority of cases, it can readily be seen what opportunities there are for improvement just along this line. It may be well to state that with the poorer stands the individual weight of the beet increases somewhat so that, in the field, the decrease in yield will not be as uniform as that given in the table. However, it is great enough to approach the figures given.

From seven to fourteen days after the seed is planted the young plants begin to appear. And then another advantage is to be noted from the heavy seeding. If the ground is of a clayey nature or becomes packed the multitude of seedlings are much better fitted to lift the soil and break through than are fewer seedlings scattered at irregular intervals. Their combined effort may be compared to men lifting a steel rail. Four or five laborers will experience great difficulty in lifting it even if they are strong men. If weak they cannot budge it. But twenty or thirty men, even if not up to the limit of strength will pick it up and carry it off with comparative ease.

In a field where rains follow the sowing and crust the land just as the seedlings are coming up, the amount of seed sown may make all the difference between a fair stand and no stand. Reseeding will be necessary in the latter case, at greater expense than the originally larger amount of seed. And if the season is getting late the time lost in regaining a stand may seriously curtail the crop.

The Time of Planting will be largely determined by local conditions, but in every case, once the land is ready, it should be planted whether it be fall, winter or spring sowing. The soil should be settled, warm, and fairly dry. A frost or two will make no difference. I have seen beets with two true leaves stand 18 degrees F. The same beets when they had twelve leaves were subjected to 110 degrees F., and stood the cold extreme better than the heat. Early sowing reduces the danger of damage from a number of insect pests.

While late planted beets sometimes look greener and have larger and more luxuriant tops, the actual tonnage is, as a rule, greater in the earlier plantings. Cool weather when the beets are coming up causes them to develop small compact foliage, but the greater supply of moisture present in the soil helps them out in the roots.

In planting, allowance must be made for late spring rains. In most sections the Equinoctial storm can be counted on in late March. As heavy winds are apt to follow, which rapidly crust the soil, planting (if planting is at all possible that early) should be delayed until the storm is past, or else put in early enough to permit the seedlings to be well above ground when it arrives.

Early planting has its drawbacks. Rains to the extent of an inch or more before the plants have four leaves are not desirable because of their crusting tendencies. The soil, however, plays an important part in this respect. Beets in adobe or clay lands suffer less than those in sandy land as the former will crack in drying and give the beets a chance to come up. Plantings in cold, wet soils will develop root rot, the conditions inducing this trouble being excess moisture and cold soils. Early planting may mean more weeds and consequently entail more crop cultivation.

But on the other hand, early planting means more freedom from insect pests, an earlier harvest, a longer growing period and more natural moisture for the crop's needs.

In the humid sections these remarks are not as applicable because the rains come at intervals frequent enough to prevent the formation of any great amount of unfavorable conditions. The rainfall is gentle as a rule. But many of the beet growing sections are in semi-arid regions and when it rains it comes right down. In humid sections when drouths follow the rains the described results will exist, and give a state of affairs similar to those of the west.

But whenever planting is to be done, the land must first be put into shape, and until this is brought about, sowing must be delayed. It is essential that the land be well pulverized, as clods seriously interfere with germination by obstructing the advance of the sprout and by interfering with the movement of the soil moisture. Such soils dry out badly. One-quarter to one inch of soil is sufficient to put over the seed. When the seed will germinate evenly at this depth it means that the land has been properly prepared and the moisture kept right at the surface. If a greater depth is needed to get an equal germination it indicates that the soil is not in the best possible condition. Fineness of soil is the greatest factor in securing a stand. When the soil is right the seed will come up well whether it is put down one-half inch, one inch, two inches, or even more, or whether shoes or wheels are used on the seeder to cover the seed. Moisture to germinate the seed must rise from below fast enough to start germination and to compensate for evaporation from the surface of the ground. The finer the soil, the better is the proper moisture content maintained. Therefore, as germination depends on moisture, and the amount of moisture is directly dependent on the fineness of the soil, we may say that germination depends on the fineness of the soil, or soil preparation.

The seed must be placed where it will receive a constant supply of moisture until it has a chance to start. This depth should be carefully determined. By scraping away the soil with the foot, or by digging down with a penknife the boundary of moisture and dry soil will be quickly discerned by the change in color from light to dark where the moisture begins, unless the soil is uniformly moist to the surface. The seed must be put into the moist soil.

As the seed should not be covered over one inch deep, when the moisture is lower than this depth clod removers must be used on the seeders to scrape away enough of the dry soil so that the seed will be placed in the moist soil. The seed is then covered one inch deep. It is desirable to keep the land as flat as possible, not in hills or ridges, and everything should be done to make this possible.

The rut in which the seed is dropped is comparatively narrow, so that large seed balls will not reach clear to the bottom. Care must be exercised when using a brand containing a large number of big seed balls to run the seeder deep enough so that they will be placed at the proper depth. The seed balls should rest on a well-firmed soil. It is better to do this and cover with dry soil, than entirely to surround the seed with loose, moist soil. This tends to dry out before the seed has time to germinate.

For drawing the soil over the seed, shoes are to be preferred to wheels when the land is dry on top. They pack the soil over the seed, draw soil to it, regulate the depth better, can be weighed to better advantage, and the seeder draws easier.

On moist land, especially that of a sandy nature, wheels are best, for the shoes tend to smear the land so that it bakes into a crust as it dries, even without rainfall. The wheel does away with this disadvantage. The author is only considering the wheel with the concave rim—the kind with the flat rim is not so good. In land of this nature it presses the soil firmly on each side of the row of seed, but leaves a fine line of unpacked earth down the center, which will absorb water if rains come and allow the seedlings to reach the surface without difficulty.

The size of the seed ball is unimportant—it is the size of the seed which counts. The larger the seed the greater amount of nutriment is stored in it, and as it is this nutriment which gives the impetus to the seed, the more there is the better will be the resulting growth. Seed containing the greatest amount of medium sized seed balls containing plump, well-filled, bright-colored seed is preferable. It will sow more evenly, will sprout quickly and evenly, and the resulting stand therefore, will be more uniform.

The large seed balls usually contain more seed but the germination is slower as the thick wall requires more time to absorb moisture, hence it is the last seed to sprout. Moreover the large seed balls are usually the exception rather than the rule so that smaller seed is also present. It will, therefore be difficult to regulate the seeder properly to take care of all sizes. Because of the irregular rate of germination, and different distances from the surface the stand will appear uneven and the seedlings will not assist one another in breaking the soil away to reach the surface.

The presence of green or black seed often causes question as to its desirability. But if the seed itself is plump and full (the seed ball must be cut open and the seed picked out to ascertain this) the germination will be found to be equal to the rest of the seed.

Distance of Rows.—The distance between the rows will depend to a large extent on the character of the land. They should never be closer than 18 inches nor further than 30 inches. Twenty inches is perhaps the best average. Lands deficient in fertility or poor in moisture-retaining power cannot stand close planting.

The nearness of the rows to some extent, will determine the space to be left between the beets in thinning—a matter which will be taken up later on. The greater the thinning the nearer the rows can be.

For all around purposes 20-inch rows with 10-inch thinning will serve as a general guide.

Seedling Growth.—From the time the seed ball is planted and gathers the necessary moisture to burst its walls, until it reaches the surface of the ground, the little sprout makes its growth entirely on the nourishment stored in the seed. Not until the *cotyledons* (seed leaves) are unfolded above ground does it draw on the soil for support. The rootlet appears from the seed ball first and grows downward, often to a considerable depth. Dr. Briem reports an experiment in which the growth of the rootlet made a daily average increase of .55 inches. The total growth on the nourishment of the seed was 3.27 inches, and covered a period of six days.

Different rootlets grow to different depths during this period depending on the amount of food stored in the seed cell. This is shown by the size and weight of the seed. The greater the amount of food stored the longer is the possible growing period and the deeper the root will reach. For average conditions the roots go down 3 to 3½ inches. The stalk does not start until four days after the root tip shows. But it makes a rapid growth in order to reach the surface quickly and begin to supply the young plantlet with a supply of food independent of that stored in the seed, and it is necessary that this be accomplished quickly for the stored food will last but a very few days at the outside. The deeper the seed is planted the longer will be the period consumed in reaching the surface, and the greater the drain on the seed reserves. After the sixth day from the time the first tip appears growth will cease, and if the seedling has not reached the surface in that time it is in danger of dying from starvation or suffocation. As has already been shown, the character and preparation of the soil plays an important part in this respect and will either help or retard the advance of the plantlet stalk. Crusting or packing over the young seedling will seriously hamper its growth and may retard it to such an extent that it will die before reaching the surface. Even if the strongest plants do reach the surface under such adverse conditions they will not have the capacity for growth which otherwise they would possess.

To show that the depth of planting is very important experiments were conducted to show the number of seedlings which reached the surface of a series planted at different depths, for the deeper the seed is planted the poorer are its chances for reaching the surface. It was found that with the beet seed planted at depths of approximately three-fourths, one and one-half, two and a quarter, 3 and 4 inches, the seedlings appeared above ground after five days for the shallow depth; six days for the next; eight days for the 2¼, after ten days for the 3-inch and none at all for the 4-inch. Of the different amounts, 100 per cent came up of the first two; 75 per cent of the 2¼ depth; 50 per cent for the 3-inch and 0 per cent for the 4-inch depth.

Therefore, the more shallow the seed can be planted the better chance it has for producing a perfect stand. Beets planted too deep are yellow and sickly on reaching the surface if they come up at all, and never make as good a showing at the end of the season.

Crusting.—The course to be advised when rains follow seeding so closely that a crust forms before the little plantlets have a chance to reach the surface, depends on the stage to which germination has progressed. If the seedlings have reached the crust "spiders" (wheels with spikes in the rims), must be employed as these will break the crust without disturbing the young plants. If the seedlings have not reached the surface the use of a harrow with the teeth driven back or thrown so that they will drag lightly over the ground, or a brush harrow, will break the crust and let the plants through. This work is only possible after the land has dried sufficiently to hold up the work stock.

The spiders travel directly on the rows, the harrows are run across them and work up the entire land. A few plants may be destroyed but the loss will not be great.

Seedlings which have reached the crust, curled down, and turned yellow are too far gone to save. For such fields replanting is the only remedy.

Selection of Varieties of Beet Seed.—The selection of the proper brand of beet seed to use is important and will, to a large extent, determine the crop receipts.

In the development of the sugar beet from the common garden variety two lines of improvement have been followed by commercial seed growers, with the object either of increasing the tonnage yield, or increasing the sugar percentage of the beet. These are two opposed physiological characteristics and the highest state of development of both cannot be found in the same beet. If the type is of high sugar content it will be reduced in weight; or, on the other hand, if heavy weight is desired a certain amount of sugar must be sacrificed. Commercial brands of seed run to neither extreme, as, to serve both grower and mill, there must be a combination of sugar and tonnage. However, within certain limits, types have been placed on the market and dealers list their seed with a short statement of its capability, as:

Type A—For highest sugar content.
Type B—For highest tonnage.
Type C—For high tonnage on poor land.
Type D—For highest sugar per acre, etc.

In general, the two extremes may be considered as quick-maturing and slow-maturing. The quick-maturing is usually rich in sugar, rather light in weight, and ripens early. The late-maturing is of slower growth, but because of its longer growing season is heavier than the other, ripens later, and does not carry the sugar content. Early-maturing varieties lose considerable sugar if not harvested at time of maturity, although, when ripe, they are higher in sugar. Late-maturing kinds, on the other hand, are apt to be deficient in sugar if harvested too early, that is before fully ripe. For this reason it is well to plant part of the land to each variety when the harvest must extend over a considerable period. Here again local conditions may enter which may cause one type to be pre-eminently better adapted to the section, but when both are equally good in their respective ways the use of an early-maturing type for the first of the harvest and late-maturing type for the last half is well worth considering. By this means a steady supply of high-testing, mature beets can be delivered throughout the harvest season, even though the period covers several weeks. This shows the value of being posted on the characteristics of the kind of seed planted, for it is just as important to give the beets the right length of time to mature, as it is with potatoes, grains or any crop where different varieties require different times for maturing. Only in this way can the maximum sugar and weight be obtained.

The farmer can best leave the selection of the proper kinds to the mill agriculturist whose judgment and experience better fit him to determine the relative merits of each.

The amount of seed grown in the United States is limited, practically all we have coming from Utah and Washington. The high cost of labor seems to be the controlling factor in this respect, for the seed produced compares very favorably with imported seed—the fact that it is somewhat acclimated no doubt accounting for this to a large extent. As a rule it is somewhat freer from weed seed.

Germany, Austria, Holland, Poland, Russia and France are producers of beet seed. Most, if not all, mills import their own beet seed direct from the foreign grower, thereby gaining a number of advantages not open to the individual grower. For instance, the initial cost of the seed is less in large quantities, freight rates are reduced, while the possibility of redress in case of error is much greater. Moreover, it is very essential to know the existing conditions in Europe for the periods the beets are growing which are to produce the seed, and while the seed itself is developing. Poor keeping of the mother beets, extreme hot or cold spells of weather at critical times, drouth during the growing season, insects, disease, rain at harvest or frosts may cause entering factors well worth considering in the purchase of seed.

To make a profitable run the mill must have the beets to work, and the selection of the proper seed is of paramount importance to them. Their purchase of brands is based on careful compilations of field work from their own and government experiments followed up with careful germination tests, and examinations for weed seeds when the seed arrives.

It requires several years of field testing to determine with accuracy the seed which will give the best results year in and year out. Not only must climatic conditions and variations be taken into account, but different soils require different brands. To determine these factors requires accurate voluminous records, a knowledge of the section where the seed was grown and its pedigree. When the work is supplemented by comparative tests of different brands handled exactly alike in the field—a local test not at all unusual—it is evident that the work of trying out the value of different brands can be handled much more properly and profitably by the mill than by the individual grower.

The germination tests refer to the starting power of the beet seed and is similar to the methods advocated for seed testing in general.

In this connection a discussion of the relation of the mill to the kind of seed may well be considered. As the mill buys beets at a set price per ton, or on sugar percentage, and as the mill has the opportunity to select seed, it has been stated that the mill has a chance to regulate the crop to suit itself, by choosing brands which will give the required results at the least cost to themselves. But anyone familiar with the details of sugar beet districts is aware that mills cannot afford to do so—at the present time anyway. All the mills require a large, steady supply of raw material, more than they obtain as a rule, and to secure this supply they are only too willing to institute such systems of payment as will make beet raising an inducement. The system of payment adopted is the one which gives the most satisfaction to the greatest number of growers. The system also carried the bonus idea. If greater acreage is wanted the tonnage basis is offered; if more sugar the percentage basis is used, while in many cases a choice of the two systems is given. In each case, however, the system is intended to accomplish the mill's desires by offering an increased rate of payment.

Most factories buy two or more brands of seed for distribution and the grower who complains that he receives a brand which favors the factory has several recourses open. First, he should compare the returns from land in his section of the country with yields from other beet growing sections using the same brand of seed and determine if the difference is not due to his soil conditions or to his faulty methods of growing. He should also inform himself concerning the brands carried by the mill and choose the one which fulfills his needs most perfectly. And, lastly, any factory is willing to permit a grower to buy his seed elsewhere if he wishes to pay the higher price, provided it is sugar beet seed and the resulting crop comes up to the mill requirements. The farmer gets protection, however, in the fact that if dissatisfied with his beet returns he can and will turn to some other crop, and as this is possible in all sugar beet localities because of the agricultural possibilities of the section which makes it suitable for beets it behooves the mill to cater to the wants of the farmers for, as stated previously, one of the biggest problems of the average sugar mill of the present day is to secure more beets. The mill must have beets, not only for one season but for years to come. The investment of capital is great and can be repaid only by many consecutive sugar making campaigns. The supply of beets must be steady to bring up the sugar output and for that reason alone if for no other, the mill could not afford to adopt a short sighted policy which would be bound to result in discontent among the farmers. For in times of high prices for other farm products, such as grains, hay, potatoes, beans and the like, the tendency would be for the farmer to decrease his beet acreage at the first opportunity at the least hint of ill treatment.

Growing Beet Seed.—The growing of beet seed is beyond the scope of the farmer unless he devotes all of his time to the work. It is a special problem, requiring time, capital, experience and knowledge of breeding principles. For this reason combined with the scarcity of cheap labor seedsmen have been slow in taking up the work in this country.

While in many instances it may pay the mill to grow its own seed, the amount of capital involved and the number of years to produce a sufficient quantity, means that forethought is necessary before embarking on the enterprise. The following will outline roughly the routine for securing a steady supply of seed.

To locally grow a constant supply of seed for a section requiring 60 tons per year, 10 acres are first planted with the best seed obtainable. A yield of about a 120 tons of beets will be secured from this planting, 13 of which will be removed and siloed, while 107 tons are marketed. The second year the same thing is repeated. In addition the last year's beets, the mother beets, are tested for sugar percentage, and those coming up to a required standard of sugar are planted out. Only about one acre is needed for this, as not more than two tons will come up to the requirements.

In the fall the seed from these mother beets is harvested, cleaned, graded and stored. The beets from the other field are treated as were the beets the year before.

The third year the operations of the first two years are repeated in the successive way in which they were done before. The seed of the second year is planted on 10 acres of fertile ground to produce very small, rich beets. The fourth year, the cycle is repeated and continued as in all previous years, as the aim is to keep a constant supply of seed coming in all the time. The small "stecklings" grown from mother beet seed in the third year are planted in 100 acres of land and these produce the seed for the factory's use.

To produce this amount of seed will require about 600 acres of land, taking crop rotation into account, but the 60 tons of seed will be worth from 10 to 15 cents a pound, or $12,000 to $18,000, a sum probably far in advance of the cost of producing the seed.

Treated or Decorticated Seed.—This is seed treated with some process (involving the use of sulphuric acid) which removes much of the outer coating of the seed ball. This makes the cell walls thinner so that water is absorbed more rapidly by the seed and germination is promoted. Germination with this seed is increased, being forty-eight hours ahead of the untreated, but on the other hand the hull of the seed seems to contain a certain amount of nutriment available to the young seedling, and as the number of seed to the ounce between the treated and untreated is about the same, the use of this sort of seed would be confined to special situations, requiring quick germinations. Further disadvantages are the greater liabilty to germinate when stored, and to rot in the soil if germination is delayed after planting.

Hulled or Shelled Seed is seed with much of the ball removed by mechanical means. The remarks under "Treated Seed" are applicable here. Some seed is on the market which has been treated with a combination of the two methods.

Single Germ Seed.—In order to do away with much of the hand labor incident to thinning, the United States Department of Agriculture is working on the development of beet seed which will contain but a single sprout. Should such seed be secured in quantity, true to type and vigorous in character, it may prove a most important aid in lessening the cost of thinning, although heavy planting must still be considered the rule in order that the seedlings may aid one another in coming through crusts and the like.

Thinning Beets.—When the beets have from four to six leaves they are ready to thin. Thinning must be done promptly. If the undertaking is large it is better to begin when the beets are too small rather than to let them go so long that in thinning the last beets the work will have been so delayed that these are suffering for want of attention. The larger the beets the more the roots of those to be left will be disturbed and the harder the condemned ones will come out. If they pull hard the tops are apt to be broken off, and the roots will add forth new foliage so that double beets are the result.

As to the spacing of beets, no definite law can be formulated which will cover all conditions. The German recommendation of 144 square inches usually must be doubled, if a 1½ to a 2-lb. beet is desired.

When the rows are 20 inches apart the results from close spacing are usually the most satisfactory. The thinning must be suited, however, to the character of the soil, the amount of water available throughout the season, and to local conditions. For lands rather apt to have insufficient moisture from either the available supply, or from the naturally poor moisture-retaining power of the soil greater distance between the beets is necessary than in the heavier class of soils receiving a more bountiful supply of water. The beets must be near together if it is desirable to shade the land as quickly a spossible to prevent the sun overheating the soil.

Near thinning (4 to 8 inches) will give the greatest total yields, but the beets mostly are too small for easy topping and handling. Contract labor will neglect many of these.

The supply of moisture and the retaining power of the soil, its natural strength as regard plant foods, and the distance apart of the rows are the factors to be considered. In sandy, open land distances of from 10 to 18 inches will prove best, while 6 to 12 inches will be enough on rich, well moistened land.

As a general rule a space of 10 inches between the beets, when 20-inch rows are used will prove a general guide.

In thinning, care to select and leave the largest plants will always pay. In a trial of this kind at the time of harvest the beets where care was used in thinning averaged 3 ounces more and tested 2.5 per cent more in sugar. This is not surprising, as the largest beets having no setbacks are most vigorous. The smaller beets are slower in reaching the surface after germinating, and consequently are not as vigorous when they appear, or they are beets damaged by root rot or insects in their earliest stages.

Cultivation. Frequent and thorough cultivation of the beet field is desirable at all times to preserve a surface mulch which will conserve moisture, destroy weeds, bring about air circulation in the soil, destroy shallow hardpans formed by working the soil and permit rapid and easy making of furrows for irrigation.

Start the cultivators early, as soon as the beet rows show, and keep them going later, whenever the moisture conditions of the soil is such that the earth will not bale or pack in working. Most successful beet farmers cultivate from four or five times, while a few cover the field seven or eight times.

The kind of cultivator tooth to be used is one which will thoroughly stir the soil to the greatest possible depth —four, five, six or even more inches—without disturbing the beet root. Sometimes narrow deer tongues, one to the row and two rows to a team, will be all that can be used. In other soils the duck feet, or the weed knives doing four rows at a time will give the desired results. Only a study of the actual field work of the different implements will determine the kind to use.

Where the rainfall is the source of moisture supply much can be done to alleviate unfavorable conditions of excess or scarcity of water by providing good drainage and giving thorough surface cultivation.

Cultivation will serve a purpose but it must not be counted on to take the place of proper soil preparation. This is far more important than subsequent crop cultivation.

Growth of the Beet.—The handling of the land during

27 TONS TO THE ACRE.

preceding years has a marked influence on the growth of the beet. The kind of crop, the depth of plowing, the shape in which the land was left at time of harvest, the number of irrigations and the amount of water applied, etc., all have an influence.

Beets will not do well on raw new land or on poor lands, whether the trouble be lack of plant food, or too much or too little moisture. Beets will not follow some crops to advantage, a matter which will be discussed under "Crop Rotation."

The beet will stand periods of hot weather if there is ample moisture in the ground, but when the moisture decreases, especially in the first few inches of soil so that it heats up badly the plant is apt to suffer. The outer leaves turn yellow and die and the plant begins to wither. The beet may, and usually does, revive over night and appear vigorous the next morning, yet if the hot weather continues and no supply of moisture is forthcoming, it turns woody, dries out, and if small, burns up in the ground. Beets will wilt and show a yellow leaf here and there in land with plenty of moisture if the top soil becomes heated, but under such conditions will seldom suffer seriously and always make a good crop.

Because light soils dry out quickly the beets are apt to suffer more than in the better moisture retaining lands. While beets will survive these sudden hot spells of weather, they are not desirable and the effect will be seen in a drawing out of the leaves and a yellowing in the color of the foliage, a condition which is overcome, however, with the coming of normal weather. If such spells can be counted on at certain periods, early plantings to get the beet as far ahead as possible before they come will prove very advantageous.

In general, the conditions governing the plant's growth with reference to sudden change of weather may be summed up as: (a) Cool weather forces growth; (b) hot weather forces ripening.

Harvesting.—The time of harvest depends on the number of acres, the amount of help available, the weather and other local conditions. To secure the best results on large tracts it is advisable to grow both early and late beets. If the work extends over a long period and only early maturing beets are grown the last of the harvest will result in beets of a lower sugar percentage—as quick maturing beets are at their maximum sugar content when first mature. Ten days after a slight decline sets in, which, although not great, will reduce the total sugar output. This is important to the grower who sells on a percentage basis. Moreover, should wet weather set in after the beets mature and before they are harvested, secondary growth may start preparatory to the formation of seed and will be accompanied by a decrease in the sugar content.

If all the beets are of the late maturing kind the greatest returns will not be secured at the beginning of the harvest either with respect to tonnage or sugar content—if early plowing out is necessary.

A well balanced planting of each type will give the best returns to both grower and mill.

Plowing out should be delayed until the beets are ripe. Maturity will be indicated by a yellowing in the color of the leaves after the beets have been in the ground four months or more, accompanied by a slackening of growth and a ring of dead or dying leaves around the outer circle of the beet. Sometimes drying out is confused with ripening but this occurs where the moisture conditions are unfavorable. Where this occurs the seemingly ripe characteristics will appear more or less abruptly and the root will be soft, dry and rubber-like. Mature beets are solid, brittle, juicy and with a sweetish taste.

In addition to the appearance of the field sugar tests of the beets themselves are sure guides to the degree of ripeness. For testing, a sample of ten beets should be selected. The individual variation of the beets is so great that never less than ten beets should be taken. In taking samples a rough estimate first should be secured of the different types of beets in the field, and an attempt then made to proportion the number in the sample to correspond as closely as possible with the field conditions.

Beets should contain at least 12 percent sugar. The sugar content rests largely with the grower. The mill cannot make sugar—it can only extract it. The sugar is put into the beets in the field under the influence of the conditions surrounding it. While the grower cannot

HAULING BEETS.

control the weather conditions, he can, to a great extent, influence the crop by providing proper conditions of seed-bed, thinning, irrigation, cultivation and harvesting.

The purity of the juice refers to the amount of sugar in it as compared with the total amount of salts present. Contained in the juice of the beet are substances in solution other than sugar, present in quantities of from 10 to 40 per cent or more of the whole, such as proteins, nitrogenous matters, and the like. It is the presence of these substances which make sugar extraction expensive—the cost being several times increased over the increase in amount of foreign substance, because of the gelatinous nature of these impurities which makes separation much more difficult. They also decrease the amount of sugar which can be extracted. If these impurities pass into the sugar they impart disagreeable odors and discolorations, thus seriously impairing the market value of the sugar. As only a small percentage of these impurities is necessary to obstruct mill operations, a comparatively pure beet is the only kind fit for sugar making purposes. For this reason the factory must insist that beets test at least 80 per cent purity. In other words, it means that of the total substances dissolved in the juice of the beet four-fifths must be sugar. In speaking of the sugar content of the beet, however, reference is made to the percentage of sugar based on the weight of the whole juice. That is, a beet testing 15 per cent sugar has fifteen hundredths of its juice pure sugar. Based on the total weight of the beet as it comes from the field the sugar content is from 93 to 96 per cent of the amount in the juice—or an average of 94 per cent.

Purity is dependent on a number of factors in the field, such as the amount of sunshine, fog, soil moisture, strength of the land, uninterrupted growth of the plant, temperature of air and soil, and so on. Any condition which will prolong the time of ripening will keep the sugar down. A thoroughly ripe beet is always satisfactory in point of purity.

The time of ripening is influenced by: (a) Cold nights or days; (b) foggy spells; (c) hours of sunshine; (d) moisture in the soil; (e) character of the soil; and (f) newness of the land.

Usually orders for harvesting come from the mill, based on tests of the grower's beets. A steady supply of beets is required to run the mill to advantage and at the same time avoid an overstock because an excess is liable to decay in the bins if left too long. Such beets are worthless for sugar purposes. The superintendent is obliged to gauge the receipts of beets according to the mill's requirements. In favored localities the beets can be left in the ground until the mill can receive them but where severe spells of weather occur with alternate freezing and thawing the beets must be given protection. The added cost of handling, however, is borne by the mill, by paying more for such beets. The mill men are shouldering their share of the burden.

Siloing.—The usual method of protecting beets which must be dug and cannot be delivered at once is by siloing. If siloing is found necessary, any method which will prevent decay and drying out is good. An atmosphere not too dry with proper circulation of air will do wonders in keeping beets in good condition. Good results in siloing are secured by leaving the top of the silo open and covering with a light coat of beet tops while the beets go through the usual sweat and while cold weather comes, when they can be safely covered with soil. Old straw can be used between the beets and the soil to good advantage. If the soil surrounding the silo is dry it can be wet sparingly but thoroughly. The idea is to equalize moisture conditions so that the earth will not draw from the beets in order to bring up its moisture content. This is done away with by wetting the soil. Experiments run in Colorado show a loss of only a little over 2 per cent in weight in beets put in a silo of this kind which was previously moistened, while the beets in a similar silo left dry lost over 5 per cent during the same period.

Long, rather low, wide piles of beets are preferable to high conical piles.

Handling the Beets in the Field.—The easiest way to handle the beets after they are plowed out is to gather nine rows together in a long windrow with the roots extending all in the same direction. The topper then comes along on his hands and knees. The usual method of cutting with a knife can be facilitated by clamping a small pick extending one inch below the blade on the end of the knife. The next beet to be topped can be picked up with this without the necessity of bending over. The use of this presupposes that they will be worked up immediately at the mill before there is danger of rot setting in at the exposed place. Beet knife tips are sometimes objected to, however, on the ground that they open a certain number of sugar cells from which the sugar is lost during the beet washing process at the mill.

As the beets are topped, an improvement over throwing them into piles is for the topper to stand them on end right by his side. This will take less time and effort than throwing into piles, reduces evaporation from the cut end, and greatly facilitates loading by hand when the wagon comes along. The beets can be picked up by the tails and two rows of topped beets will be loaded at once. The saving in energy and time on the part of the laborers will well repay the effort spent in breaking them in to this method if they are not already accustomed to it.

The preceding recommendation applies, of course, to half-pound beets or larger.

Topping Beets.—A question often puzzling to the farmer is where to top his beets. Shall it be just below the leaves, half way to the ground line or at the ground line?

The answer to this question is to be found in an analysis of the beets.

It has been found that a crop of 20 tons of roots per acre will analyze as follows:

Section of the beet.	Yield per acre. lbs.	Potash. lbs.	Phosphoric Acid. lbs.	Nitrogen. lbs.	Lime. lbs.	Total. lbs.
Whole beet	72,000	387	116	173	224	1,350
Tops cut at ground line	32,000	235	80	113	208	1,063
Roots	40,000	182	36	60	16	287

The figures represent the number of pounds of the different plant foods taken and used up by the different parts of the beet and the beet as a whole from the soil in one acre of ground.

A glance will show that the smallest loss to the land will consist in topping at the ground line, as the "tops" in the table refer to the growth above ground, while the "roots" is the part underground.

The sugar in the beet is all that the mill can use. This sugar is "concentrated sunshine"—not plant foods. Therefore, it stands the farmer in hand to sell as much sunshine and as little plant food as possible. Moreover, the mill will deduct a certain percentage for green tops as they contain the very salts in largest proportion which makes the extraction of sugar difficult. This deduction is really a protection to the farmer, although few farmers fully appreciate the fact. They keep on sending in beets with green tops receiving a 4, 6 or even a greater percent reduction on them, thus not only receiving nothing but paying the freight and hauling on them and robbing the land of its most valuable ingredients.

This represents on a 20-ton crop of roots:

Nitrogen at 14 cents	$15.82
Phosphoric acid at 4½ cents	3.60
Potash at 6 cents	11.75
Total	$31.17

All of this is not sold with the beets, of course, but it is a sum of money which need not be drawn on at all and will then prove more satisfactory to both the farmer and the mill.

With certain classes of labor it is almost necessary to stand over the workers with a club (figuratively speaking) to insure proper topping, but this pays if it results in correct topping.

The disposition of the tops after the harvest is often a pertinent question. From the analysis it is plain that the tops should never be hauled off the land and fed unless the manure is returned intact. Constant hauling off with no return will mean the eventual purchase of commercial fertilizers.

The best method is to scatter the tops and plow them under green. This returns humus and all the plant food. Green tops will contain three times as much humus as dry tops or as the manure resulting from feeding. Next to plowing under green is plowing under dry. Third, is feeding to stock on the ground. As long as the soil remains dry so that the tramping of the soil will not puddle it and put it in poor physical condition, feeding is very nearly equal to plowing under the dry tops as the manure contains about 80 per cent of the total plant foods removed by the crop. More will be said of stock feeding under the consideration of "Feeding By-Products."

Schedules of Payment Determine the Beet to Grow.—A beet weighing two pounds, symmetrical in outline, well-ripened, with small crown and compactly placed leaves, containing a high percentage of sugar of excellent purity is the ideal beet to grow. But the kind of beet the farmer will grow depends on the character of his land and on the mill requirements. This is shown in the schedules of payment offered by the mill. They are based on, first, a desire to stimulate interest and to insure the growing of sugar beets; and, second, to influence the grower to raise the sort of beet desired by the mill. If raw material is wanted the mill offers a flat rate per ton; if sufficient raw material is forthcoming and the mill wishes to raise the quality of the beets it does so by paying for beets on the sugar content basis. In this way a bonus is offered for high testing beets. Often a mill offers a choice of the basis of payment.

By tonnage payment is meant the flat rate payment offered for beets by the ton. This varies from $4 to $6, and even more for siloed beets. By sugar content payment is meant the payment for the beets on a plan based on the sugar content of the beets. In other words, the mill recognizes quality. Rates vary considerably at the different mills for quality payments. An example is the following: Beets testing 12 per cent sugar will be paid for at a rate of $4.25 per ton, with an increase of 25 cents for every additional percent of sugar over twelve. By this method, for beets testing 18 per cent the mill would pay $4.25 for the first 12 per cent and $1.50 for the extra percentage, or a total of $5.75 for each ton of beets.

Whether the mill specifies payment on a tonnage basis or on the sugar content, or gives a choice of either method, the grower should first of all do everything to get the tonnage. He should, therefore, select his strongest and best land. A study of yields from the different lands quickly will prove this point. For instance, say, the light lands on your ranch will produce 10 tons of beets per acre testing 18 per cent sugar, while the heavier, better land will yield 20 tons testing 12 per cent. Suppose the mill pays $4.25 a ton for 12 per cent beets with an additional 25 cents for every per cent increase in sugar over the 12 per cent; in other words, pays on a sugar percentage basis, then the light land would bring in from the rich beets $57.50 per acre ($5.75 per ton). The heavy land would bring in $85 ($4.25 a ton).

If the beets were paid for on the flat rate basis, the rich land would bring in, supposing the rate to be $5 a ton, $100, while the light land would bring in only half that or $50. Of course the cost of producing the crop would vary, the big crop costing more because of greater expenditures for labor, hauling and freight. Based on actual figures, however, this would be, say $27.85 for the crop on the light land and $49.35 for the heavy crop. Therefore, it would pay to select the heavy, rich, fertile land because on a tonnage basis two and one-fourth times greater profit would be made over the light land; while on a sugar basis it would give one and one-third the profit of the light land.

Carrying the point one step farther, leaving aside the question of choice of land and confining attention to a choice of payments it is evident that on the light soil greater profits can be secured from the sugar basis while the reverse is true on the heavy land. Here the tonnage receipts are in excess, being $85 against $100. In each case the cost is the same.

The foregoing example illustrates the importance of a proper selection of land for beet growing and of studying the payment schedules. A mill wanting sugar makes inducements to get it, while a mill in need of raw material will make it worth the grower's time to raise quantity instead of quality.

Generally, warm, light lands will produce early crops, rich in sugar and only fair in tonnage. The heavier type of lands, as clay loams, will run to tonnage production and less to sugar.

Labor Problems.—Every sugar beet grower who is raising beets to any extent at all is confronted with the labor problem, for beet growing requires much hand labor, especially at thinning and harvesting times. Scarcity of labor and high wages are doing much to stifle the industry. When a man puts in only enough land so that he and his family can do all the work themselves the work is taken care of automatically. But for large acreages requiring much hired help the problem grows in extent as the acreage increases.

Best results come from hiring labor on a time or tonnage basis. To have the labor done by piece work, that is, by the row or field, is not at all satisfactory. The time work has its objections as well, but is an improvement over piece work. For best results with a fairly intelligent class of labor, the sliding scale tonnage basis of payment is proving the most satisfactory. The tonnage basis alone fixes a set price to be paid for the hand labor based on the yield of the field and is offered to contractors (Chinese, Japanese, Mexican or the like) who guarantee to furnish all the help needed for properly thinning the beets, hoeing weeds from the rows, cleaning irrigation ditches, handling the irrigation water, and at harvest for pulling, topping and loading the beets onto wagons. This scheme has worked fairly well for a long time, especially in California, but the wily contractor soon began to discriminate between the fields on different soils. A growing scarcity of labor made this still more apparent, and also forced the contractor to pay higher wages so that he was compelled to ask more money for his work in order to protect himself. A farmer then raising beets on poor land or by poor methods suffered by the greater price asked of him, supposing he was able to get some one to handle his contract at all. To equalize matters for both contractor and grower many sections adopted the sliding scale tonnage basis. In this scheme the different yields per acre are recognized and the pay proportioned according to the yield. In fact, the method merely brought to a uniform plane the methods being practiced in a haphazard manner by the labor contractors. Thinning is as expensive on one kind of land as on another where the stand and soil preparation is the same. Then at harvest the work in handling the beets is proportionate to their weight, being greater for the smaller beets. This scheme is worked out on actual cost of the work and gives a high rate for low yields and a low rate for big yields, the rate thus decreasing as the yield increases. In this way a basis of payment mutually satisfactory to all concerned can be worked out for all conditions.

Where labor conditions are especially bad, care in working the land to make it as smooth as possible and to destroy the greatest number of weeds will aid materially in cutting down the cost of maintenance. If the surface of the ground is cloddy the time and fatigue of thinning is greatly increased. If cultivations are neglected the cost of extra weedings must be borne by the crop.

The use of the best types of farm implements is worth mentioning in this connection. Money spent in the purchase of improved modern sugar beet machinery or for any other kind of farm work for that matter is well invested.

Irrigation.—There is nothing equal to natural rainfall for beets. Not only does it soak into the ground better than irrigation water, but it soaks levees, ditch banks, and other necessary high spots which are inaccessible to irrigation. Rainfall also lessens evaporation. This is accomplished not only by the fact that moisture is gained from the clouds during rainy weather, but also because evaporation from the fields is reduced to almost nothing. Moreover, when evaporation does again set in the drain from the beet land is not as great as it otherwise would be because the whole surrounding country is soaked. When any portion of the country is dry it heats the atmosphere, and as dry air makes big demands upon the soil for moisture, the irrigated fields are forced to give up more in proportion than they would otherwise be obliged to do.

On the other hand, the opportunity to put water on the fields when the crop is in need of it, the less danger of rains interfering with the farming operations, or with the crop during maturity are big advantages in favor of irrigation.

Preparation for Irrigation.—The construction of irrigation facilities will pay in many localities even when, in general, the rainfall is sufficient. The use of a small quantity of water at just the time the plant requires it will mean an increase in the final returns. Should the rains come nothing further need be done, but if no rain does fall when the beets are in need of water, then the supply of irrigation water will be appreciated. I believe that in many sections where full dependence is now placed on the rainfall that a judicious amount of irrigation facilities will prove to be a paying proposition.

To put in an irrigation system is by no means a very difficult job, although it is a subject requiring forethought and study. Various factors enter into the planning of a system and each must be considered, not only separately but in connection with the scheme as a whole. A few of these are:

(a) The source of the water, whether stream or well;
(b) The necessity for storing;
(c) Whether a sufficient quantity is available; this depends on: the distance it must be carried; the character of the soil in the field and in the ditch; the amount of land to be covered; the number of men using the water; the height of the stream above the land (if a stream is the source) at the time when water is required;
(d) Whether the water is secured by gravity fall or by pumping.
(e) If pumped, the height to be raised; and the amount of water needed.
(f) The slope of the land.
(g) The amount of money available for the purpose.

Accurate determination of all the foregoing is necessary in order to arrive at an estimate of the cost and possibilities which will in turn determine the system to be used both as regards securing the water, and for proper preparation of the fields for the reception and handling of the water when it gets to them.

In most of the beet growing sections irrigation has been so instrumental in developing the industry that the systems for applying the water are well worked out. On a large scale, involving much water and considerable land, the services of a well trained, competent irrigation engineer are necessary. His training and experience will mean the installation of the most efficient system at the minimum cost.

How the water shall be put on the land once it arrives can be determined by the farmer for himself, whether his supply comes from a small private plant or from a big mutual canal. This will depend on a number of factors, such as the amount of labor available for handling the water, the lay of the land, the quantity of water available, and the amount of acreage to be covered.

When the water supply is to be developed for tracts of small area, the problem often can be worked out by the farmer himself, if the development of the project involves no serious problems in the selection of machinery or in field surveying. Even if the farmer should undertake the work himself it will usually pay him to secure the services of a good surveyor for two or three days in order properly to plan the line of ditches and the location of the checks. It is practically impossible to determine the direction and amount of slope of the land with the naked eye, when the amount of fall is but two or three feet to the hundred, or even less.

In arid sections where beet growing is an established industry or in new districts of the same nature where sugar beets are to be grown, the water supply is one of the first factors determined by the mill people. The many thousands of dollars which must be invested to put up a sugar mill means that great care is exercised in investigating the water resources and in developing a supply where one does not already exist. In such localities the grower need not concern himself with the development of the water supply, as it is brought right to the land. All he has to do is to take care of it after it arrives. It is beyond the scope of this work to more than hint at the results to be gained by developing the irrigation possibilities of a country. Many factors enter into the profitable utilization of water which cannot be touched upon at this time. But it is a fact that many advantages result from a constant, ever-ready reserve of water, which can be drawn upon when needed, even if irrigation is not an absolute necessity.

The discussion of the ways of preparing the land for the irrigation of sugar beets may well be discussed, as it is the aim of every grower to get the greatest returns possible from the use of the water. Irrigation is expensive work, and anything that will reduce the cost of handling the water will redound in greater profits on the crop. One of the most economical ways of saving is by the proper preparation of the land in the first place for the reception of the water. There are several different methods which can be used in irrigating beets, or any other general farm crops, for that matter, each of which has its advantages as well as certain disadvantages. Which shall be used largely must be determined by the prevailing conditions of the section as well as by the object sought.

In this connection the different methods must first be discussed and then the proper way of preparing the land for these methods.

Methods of Irrigation. A number of methods are practiced such as:

1. Flooding, by means of
   (a) Slip pipe,
   (b) Contour level checks,
   (c) Rectangular level checks,
   (d) Sloping checks.
2. Furrows.
3. Ditches.
4. Underflow.
5. Subirrigation.

The slip pipe method consists in the use of galvanized iron pipe made in 12-foot lengths with the ends so fashioned that one joint will fit into the next and make a fairly tight connection. The pipe is laid to the part of the field to be irrigated, and as fast as a piece of land is irrigated successive sections of pipe are slipped off until the line of pipe is exhausted, or until the section of the field to be watered is completed.

With the check system, the land is surveyed, graded, and leveled, the water being run into basins of varying sizes (usually not over two acres being in one check). The checks either follow the natural contour of the land, following the rise and fall, or if the land is level they are made rectangular in shape. In either case the bottoms of the checks are level. The water is held in these basins by either temporary or permanent earth borders or levees.

A variation of the level check system is the sloping check or "blanket" check. These checks are from 200 to 1,000 feet long, and from 50 to 100 feet wide, with a fall of from 3 to 6 inches to the hundred feet—the greater fall for the sandy land, the lesser for the heavy soils.

With any of the flooding systems, the checks are sometimes placed in series so that the water can be drawn off from one to another, after it has stood in the first check long enough to penetrate to the required depth. When in series the fall of the land determines the position and size of the checks.

Furrow irrigation consists in running the water down little ditches scraped or cultivated out between the rows of growing plants. The water is allowed to flow slowly down these little ditches in tiny rivulets. The furrows have a fall of three to six inches to the hundred feet, and water is allowed to run in them until the soil is moistened by the percolation of the water down to the required depth.

Ditch irrigating consists in plowing out temporary ditches, 4 to 10 inches deep, right in the beet fields, for use in guiding the water in a general direction.

Underflow irrigation is accomplished by a series of underground pipes which carry the water to the various parts of the field and release it underground.

Subirrigation is irrigation by means of a natural supply of water under the soil where the beets grow, accomplished by raising the water table or by utilizing hard strata of soil for holding up the water and permitting it to spread throughout the mass of top soil.

All of these methods have their advantages and disadvantages. Around the sugar mill where the waste water must be taken care of the use of large checks are the first consideration so that large quantities of water can be handled cheaply and quickly. The irrigation serves the double purpose of disposing of the waste water from the mill, and of supplying needed moisture to the fields. It is put on at a time when the land is unoccupied so that large quantities of water can be used. This is the previous-to-planting irrigation of the crop. In many sections this one irrigation will suffice to carry the crop through the season without further application of water.

The method to employ depends on the individual case. The amount of water required by the crop, of course, is the first consideration. If crop irrigations are needed the frequency and quantity required must be taken into account, and whether the summer irrigation is united with a winter application. We can count on three conditions, winter irrigation alone, summer irrigation, or crop irrigation, alone, or winter combined with summer. By winter is meant the previous-to-planting irrigation; by summer the crop irrigations. When the winter irrigation alone will suffice, the best method is the one which will cover the most area in the shortest possible time. When crop irrigations are required, the method will depend on the climatic conditions and the amount of help available.

In countries where beet culture is a new industry, considerable experimenting to determine the proper method of irrigation will be necessary. By actually growing the beets in the field under different periods of irrigation, the requirements as regards the application of water can be determined. On this basis the subsequent scheme for preparing the land can be worked out. This is something that is usually done in determining the value of a country for a sugar mill. Once the needs of the crop are known, the method of irrigation can be planned. If the crop requires one or more applications of water when growing, the method must take this into account.

In general the advantages and disadvantages of the various systems are rather sharply defined.

The slip pipe method requires but little preparation of the land and the water can be taken to any point without loss. With high priced water this method has its advantages, but at best is costly to install and handle. For sugar beets it has but a limited use.

The check system must be based on the character of the land. Where the grade is very nearly uniform the rectangular check can be used. Otherwise the contour check is necessary. In no case can the check system be used where the land does not slope evenly for from three to fifteen feet to the mile. When the grade is steeper, high levees are required close together, and these tend to become of such height that farming operations are difficult and the cost of construction is almost prohibitive. The advantages of a properly constructed system of this kind is the opportunity to irrigate with a large volume of water and the cost of applying is less than in any other system. The cost of maintenance is small after the first year, and, with certain soils, it is often the only method which will give satisfaction. This is especially true on sandy lands where the seepage is so great that a big body of water put on all at once will prove to be about the only way to reach all parts of the field and checks alike. With flooding the distribution of the water is more even, and the amount put on can be readily gaged both by gates and by borings made in the field. The last advantage is a distinct one as the need of accurate knowledge concerning the movement of the soil moisture is of vital importance in determining the needs of the crops.

The method has its disadvantages. Surface soil must be removed for levees, the levees do not receive water equally with the rest of the field, in the heavier soils percolation does not reach beneath them, and they prove annoying when using the farm machinery. Its first cost is high, a large volume of water is necessary, and care must be exercised in using water on lands which are liable to suffer from oversaturation. In many cases this may mean the proper installation of drainage facilities. The system cannot be used in countries where excessive dry temperatures will heat the water to a point involving danger of scalding the beets.

With the furrow system the advantages consist in a saving of water from seepage and evaporation, the doing away with levees, the convenience in handling the water, the absence of soil crusts after irrigating, and the possibility of using a small head of water.

The greater length of time required to spread the water, the unequal flow which usually occurs, the uneven distribution of the water in the furrow and soil, the necessity for making the furrows each time, and the danger of using an insufficient amount of water, especially when trying to cover a large tract of land in a short time, are the disadvantages of furrow irrigation.

The ditch method has little to recommend it. It is a scheme which can be used on land requiring an unforeseen irrigation for which there is inadequate preparation. It is cheap to construct, the ditches do not interfere with farming as they are put in only when needed, and it permits the deliverance of water in continuous sheets. Its disadvantages are the difficult and excessive labor in handling, the difficulty in controlling the water, the uneven distribution, the loss of the beets in plowing out the ditches, and the necessity that the land be of such texture that sideways—as well as downward—percolation will readily take place.

Only passing reference need be made to subirrigation and subflow. With the former initial outlay is heavy, and will seldom pay with a crop like beets. It does away with surface cultivation, but this is a doubtful gain. Both of these methods are feasible only in special and exceptional situations.

Underflow or "natural subirrigation" consists in reinforcing the natural country drainage. It is available only where a cheap, large supply of water can be obtained and where the soil rests on a hardpan or the previous clay layer, which will hold up the water. Where natural subirrigation occurs, it can be made good use of, but for a general scheme of development it does not compare with others.

From the results obtained in sections using irrigation extensively the sloping check or the furrow systems will, I believe, offer the most universal satisfaction. Which of these to choose will depend on the labor available for putting on the water, the slope of the land, the amount of water obtainable, the periods when the water must be applied, and the amount of acreage to be covered in a given time. The flooding method gives the ground a more uniform soaking, and is rapid. Therefore, it requires a big head. The labor is less in handling. The furrow requires less water but necessitates more help. Where the soil tends to bake or crack, or when there is liability of scalding the plants with the water, furrowing will be the preferable method to use. If there is much irrigating up of the seed to do furrowing methods are preferable.

Preparation of the Land for Irrigation.—The first work to be done in actually preparing the fields for irrigation is to determine the direction and rate of fall. The most profitable way to do this, in the majority of cases, is to hire a surveyor to run the lines and from these determine the location of the ditches and levees. This applies to even comparatively small tracts—20 or 30 acres. This work is especially necessary when the slope is slight.

Methods have been evolved for a small amount of work by which the farmer can run his own lines. An example is the use of a spirit level, or something of that nature. Descriptions of these methods can be obtained from the nearest experiment station or from the United States Department of Agriculture, Office of Experiment Stations, Washington, D. C.; but at best these methods are crude and unless the farmer understands something of surveying he will find the descriptions rather complicated.

The main fact to bear in mind in getting the land in shape is to put it in as good condition as possible at the start. Reworking, to correct initial mistakes, is costly and unsatisfactory.

To properly prepare it, the land should first be plowed or cultivated to a depth of 8 inches. Dead furrows and headlands should be avoided as far as possible. Following the plowing, such implements as are required to put the land in a finely pulverized condition should be used.

The aim should be to work the land at the right degree of moisture in order to put it in as good shape as for a crop of alfalfa. After the soil is properly fined it should be allowed to settle and to dry on top. Leveling and grading come next.

Leveling to cut off slight irregularities on the surface will be required in every case. For this purpose a standard well made grader, wooden float, or leveller made of timber can be used, the kind which will pay best depending on the amount of the work which is to be done.

Once the land is in good, smooth condition, the actual work on the irrigation system will go forward. First of all comes the placing of the network of ditches which are to convey the water to the different parts of the field. These will be placed in accordance with the original plan of irrigation decided on. The size to make the ditches depends on the amount of water which is to be carried in them. They should be large enough to carry all the water with an additional depth sufficient to offset silting or sanding up which is bound to occur with muddy waters or where the fall varies in different parts of the same ditch. The shape of the ditch and its grade will affect its capacity. The shape will be determined largely by the implements used in making it. As a general rule it will be more or less rounded out. The grade will be determined by the character of the soil—the danger of scouring out the ditch being greater in sandy soils—and by the volume of water required. The greater the grade the more water it will carry. A fall of from one-fourth to one foot per 100 feet is usually correct.

The initial point where the water is received should be at the highest point of land under which the farmer ever expects to irrigate, and from there carried to the different parts of the farm. By winding around hills, by using flashboards, by siphoning, fluming or filling in depressions ditches can be made to carry water almost everywhere but uphill.

After the ditches are put in the character of the work will change to suit the method which is to be installed. If the land is to be furrowed, no further work beyond the making of the field ditches will be required until it is time to fix the land for the proper reception of the water, whether this be before planting or after the crop is in. Furrows are then made from two to five or six inches deep with smooth firm sides. This is most easily accomplished by means of a furrowing sled, or by attaching regular furrowing shovels to the beet cultivator frame. The sled is made of two 6x6 or 8x8, forty-two inches long. These are the runners. They are spaced and well braced far enough apart so that each runner will run in the center on either every row or of every other row of beets. The runners travel on edge and are sharpened at the forward end to a vertical wedge shape. The parts coming in contact with the soil should be faced with iron, especially at the forward ends.

The furrows are made between the rows and end in a head ditch which is plowed out parallel to the main field lateral ditch. In irrigating with these ditches and furrows only a small amount of water is turned in at once. This is made to run slowly and to penetrate deeply. The furrows should be between 300 and 500 feet long, the lesser distance for the greater slope. But in no case should the grade be greater than 6 inches to the hundred feet in light lands and 3 inches in heavy soils if the best results are to be obtained. Improvements over the usual methods of regulating the water by means of a shovelful of earth placed in the head ditches, consist of short wooden sprouts made of four pieces of lath nailed together, which is placed in the ditch bank. These regulate the flow in each ditch and do away with all danger of washing out the temporary ditch banks. A more elaborate scheme is the replacing of the head ditch with a wooden flume having 2-inch holes bored to correspond with the position of the furrows, and fitted with galvanized iron gates so that the water can be shut off at will. A further improvement over the wooden flume is one of concrete similar in construction to the wooden one.

In preparing the land for sloping checks, each check is enclosed with a levee which restrains the water put there. Where these levees shall be placed is determined by the difference in elevation of the land, as the degree of slope should not be any greater in the check than in the furrow system, i. e., 3 to 6 inches fall for every hundred feet. Levees should not be over a foot in height and, therefore, cannot include in their area more than 6 to 9 inches slope for any one check. On the other hand, with the exception of soils of too loose a character, the bottom of the check may be nearly flat. For quick, thorough irrigation some fall is desired up to the limits just stated. Broad, flat levees are to be preferred to narrow, abrupt ones. Less land will receive water when the former are employed, but the ease in working the fields is much enhanced. The levees should be built a bit higher than actually desired, as the loose soil which is scraped up to make them is bound to settle considerably through future farming and irrigating operations.

Once the planning of the levees in done the work will progress rapidly by driving the scrapers which throw up the levees across each check. These will pick up soils from the knolls and high places, carrying it to the levee, dump, pass over, fill, travel to the next levee, and so on the length of the field. This does away with turning around, and where too much cutting away is not required will work to perfection.

Whether wooden or concrete head-gates shall be used to regulate the direction of flow in the ditches, depends on the choice of the farmer, the cost of the raw material, and the amount of money available for this branch of the work. The use of the "tappoon"—a movable piece of heavy sheet iron to be driven into the ditch and extending a bit into each bank—is used in many cases for effectually shutting off the flow in the ditch and forcing the water onto the land. It will facilitate the handling of the water when using small streams. For large streams the canvas dam is finding almost universal approval. The top end of a sheet of canvas is turned down and sewed, leaving an opening through which passes a 2x4 or a 4x4 timber of sufficient length to reach from ditch bank to ditch bank. Plenty of canvas is used so that it will extend a few inches along the bottom of the ditch when the dam is in use. A few shovelsful of soil are then placed on this lap and along the sides of the canvas to hold it in place and to prevent the water working its way underneath.

All of these structures are used to back up the water so that it will flow into the checks or into the head ditches of the furrows.

Where the banks are not liable to crumble and wash, openings to the checks and head ditches can be made directly in them. To close, only a few shovelsful of earth are then necessary. Care in opening the bank so that the cut is only the width of the shovel is good, as one shovel can be placed to close the opening while another is used to fill in when shutting off the water.

In loose, crumbling soils the use of gates into the parts to be irrigated will be required. Here, as with the headgates, the choice of wood, concrete or cement is possible. The tappoon can be used to advantage here.

In conclusion, emphasis must be placed on the point that whatever land is checked, the work should be well done. Better to do a little well than to do a whole lot badly, for poor work is sure to entail subsequent increased maintenance and handling expense.

Drainage.—In close relationship to irrigation comes the matter of drainage. Much land which would otherwise be valuable suffers from a constant over-supply of moisture. This may be due to the fact that the field is low and consequently receives water from land higher up, faster than it can be disposed of, it may be due to extensive impervious hardpans, or it may be the result of over-irrigation. In any case, permanent relief will consist in draining the land or removing the contributing causes.

Drainage has a number of advantages which, in outline, can be summed up as:

(a) Removal of surplus water;
(b) Increased *available* moisture;
(c) Prevention of washing (to a certain extent);
(d) Improvement of soil conditions;
(e) Production of early soils, better for plant growth and easier to till;
(f) Aeration of the soil.

Several methods of drainage are possible but before deciding on what to use a study of the conditions which produce the excess of water is required.

Often in irrigated sections excessive applications of water on high lying lands will result in a swamping of those on a lower level. For these a ditch or drain placed along the upper edge of the field to be protected will often prove an effectual protection. It will intercept the seepage and do away with the trouble if the ditch can be placed deep enough to reach the layers of soil which are carrying the water. If hard layers definitely determine the seepage the matter is an easy one to control.

When the condition producing the trouble is not open to some such remedial measure as that just given, open ditches or tile drains placed in the field must be used to carry off the excess water, unless the cause is to be found in impenetrable hardpans which can be opened to permit the water to go through. How such drains shall be run depends on the topography of the country. Each case presents a problem in itself. Sometimes where the land is valuable and there is no cheap possible outlet, it will prove a good investment to construct a sump where the water can be collected from the drains, and then repumped onto higher levels for irrigation purposes.

The discussion of laying tile drains is a subject in itself. They offer the best final solution of almost any drainage problem. A discussion, however, of their construction and cost can best be found in literature relating directly to this subject. Beyond mentioning their possibility little can be given in a work of this scope.

In discussing the relation of drainage to beet growth two facts stand forth. One is the need of a deep soil for the plant's development. If water stands within less than 4 feet of the surface drainage is well worth considering. The other fact is the use of drains to aid in alkali work and to supplement irrigation.

Before undertaking the draining of a large tract the final character of the soil to be obtained should be carefully looked into. The author has in mind a tract of several thousand acres which were fitted with open drains at a great expenditure, as the manager of the work believed he could produce good beet land out of it by simply draining off the excess water. The result was a mass of adobe, sticky in winter, and flinty in summer. The "improvements" did not improve, for while the water was successfully removed, the resulting soil was ill adapted to beets. This fact could have been easily ascertained before the money was spent by consulting any farmer familiar with sugar beet culture.

Drainage for good land will pay. Poor land, on the other hand, cannot be turned into good land simply by drainage, unless by "poor land" is meant an excess of moisture, or alkali.

As in many other problems of ranch work, the determination of a drainage system is very important. In a country of great extent, unless the conditions which produce the swampiness can be proved to be local, a drainage scheme is apt to be of considerable extent and involve many farmers. Therefore, before any work is done a careful inquiry into the cause, extent and remedy should be made.

Practice of Irrigation. There is no general rule for irrigating sugar beets which will be applicable to all sections, or even to all parts of the same section. Local conditions play a very important part and to a great extent determine the irrigation. The time of planting, the amount and periods of rainfall, atmospheric temperatures, fogs, winds, previous irrigations, the character of the land, and the kind of beet desired are all influences which must be taken into account. In no particular section of great extent will any universal practice be equally good under all conditions. While the difference will not be as pronounced, perhaps, as between one section and another, it will be great enough to require different methods of irrigating different lots of beets.

In irrigating a man must know his soil. Not only is it absolutely necessary for him to be acquainted with its nature to the depth to which the plow goes but away on down to the depth to which the roots feed if he is to practice irrigation to the best possible advantage. This is more important with the sugar beet than with most crops because, for its best development it needs a deep soil and ample moisture. When the soil contains no impenetrable strata of clay, limestone, coarse gravel or dry soil the beet will go down deeply after water—12 feet or more, so that with soils having the water table at 4 to 10 feet, the beet will finally reach this supply of moisture, a condition noticeable in the gradually quickened growth and freshening of the beets as they secure the moisture in quantity from this source.

In order to know how much water the land will hold a study of the nature and extent of the layers of soil and the depth of the water table is absolutely necessary. Soil formations are not only apt to differ greatly from one section to another, from one man's possessions to another's in the same section, but also on different fields farmed by one man.

Close clay layers take water slowly and if these lie near the surface of the ground the application of large quantities of water will only result in saturating the soil to an extent too great for the best results. In fact, adobe subsoils, clay layers and cement hardpans are dangerous unless their existence and extent are understood by the irrigator. Such formations determine the amount of soil available for farming operations. Gravel layers are not as serious; in fact if they exist at a considerable depth, 6 or 7 feet or deeper, they are actually beneficial for they will then serve as drains for excess water.

The location of the water table should be ascertained. If this is within 10 feet of the surface with no obstructing layers between, the beets can secure water directly as they grow older. When they reach this water further irrigation is of no advantage. If, however, for any reason the plant roots cannot reach this ground water, timely irrigations must be given. In this connection it may be well to state that the moisture which the plant can use is that which comes from the water table by capillarity—the plant does not go into the standing water and drink similarly to an animal. Capillarity is the same principle of physics applied to the upward movement of water in the soil, as that which causes the upward movement of oil in the wick of a lamp from the container to the flame. The height to which water can be raised by this means depends on the nature of the soil—heights of over 6 feet have been recorded. For ordinary beet soils, however, the average height is from 2 to 4 feet, depending on the layers which make up the soil. Clay soils will raise moisture much higher than sand soils. The final height which will be reached by the moisture is greatly influenced by intervening layers of sand or gravel. The moisture will pass from the finer to the coarser soils but the total height reached depends on the extent of each kind of soil and the height to which the moisture will rise in each independently. Eighteen inches of river sand will effectually shut off capillary rise. So will 2 inches of gravel the size of a pea. In actual practice the height to which the water will rise from the water-table is not very important. Knowledge of the depth to which the plant naturally goes and the possibility of encouraging it to reach this supply of moisture is sufficient.

Every irrigator should post himself on the depth to which the irrigation water sinks, the danger of over-irrigation and the possibilities of the water table as a supply of moisture.

A couple of true examples will illustrate this. In a clay loam, with a few intervening sand layers, the water table was found to be at 8 feet in winter and 10 feet in summer. The plants grew to the water table. In this case it was found that one winter irrigation in an amount sufficient to unite the surface and soil moistures, in order to guard against the formation of a dry layer through which the beet would not go, was sufficient. This made the required irrigation light as the rainfall of 14 inches falling during the time when the irrigation was given was almost sufficient to do this unaided. The combined rainfall and irrigation started the beets and provided moisture for the greater part of the season, but the gradually decreasing amount forced the beet to go deeper and deeper until finally it reached the supply coming from below which was more than ample to carry the crop to maturity. The failing supply in the upper layers produced the right conditions for ripening the beets. The crops averaged 20 to 25 tons for fields of from 60 to 100 acres and tested over 18 per cent sugar and 85 per cent purity.

A second field of light sandy loam with a sand subsoil at a depth of 4 feet, interspersed with clay layers, had the water table down as deep as 26 feet. A supply of water from the water table for the beets therefore, was out of the question, as the beets could not grow down deep enough to reach this water even though the soil was thoroughly moistened down by early irrigation. To produce beets in quantities great enough to be profitable, several irrigations were necessary, the aim being to keep the soil constantly moistened to a depth below 10 feet during the growing period of the beet with a withholding of the water for six weeks before harvest in order to produce a beet rich at maturity. The beets were planted in February, the land having been given a previous light irrigation for preparing the land. Combined with the natural rainfall (9 inches), the land had the proper moisture content to put it into shape and to start the crop. Two further irrigations were given, both crop applications, one the first of May and the other the middle of June. The beets were harvested the first of August. That proper attention to the needs of the beets will pay shows in the yields. Twelve to 14 tons of beets were secured to the acre testing 20 per cent sugar and 90 per cent purity. Yet this land could not be considered strong beet land.

A third case which came to my attention was the difficulty one man had in getting his land into shape with the resulting poor yields of small-rooted beets with very large tops. Investigation showed promiscuous winter irrigation. Examination of the soil developed the fact that the water table was but 4 feet beneath the surface of the ground and amply able to supply all the moisture needed by the plants at any stage of their growth, except possibly for germinating the seed. The soil was not a good beet soil, being heavy adobe, but after following out the recommendation to withhold all irrigation, the far better results which were obtained in ease of working, stand and yield were little short of astonishing.

In each case cited flooding was the method employed, but the same would hold true with any method of irrigation. They show the need of determining the requirements of each particular lot of land. No arbitrary rules can be laid down which will cover all conditions. Caution is urged against using an over-supply simply because it is available, or an under-supply because of scarcity. The time and amounts to apply will be determined entirely by local conditions which in turn will gauge the needs of the plant. How the plant signals its needs and the proper way of applying the remedy will be discussed a little further on. From this discussion I believe many of the points at present not fully understood, or at least not insisted upon emphatically enough, will be cleared up, and that the subject of proper irrigation will not have quite the mystifying aspect it now has in many sections.

From the big mass of data which can be compiled regarding the irrigation of sugar beets two facts stand out forcibly, and a correct understanding of both will be of material benefit to the grower of beets. One is the need of varying amounts of water from one period to another in the beets' development while the other is the ability of the plant to indicate a lack of water sufficient for its needs.

The growth of the beet from germination to maturity can be divided into three periods as regards its moisture requirements. During germination only a moderate amount is needed. But as soon as the beets have grown six or eight leaves they can use enormous amounts of water, and at this time it seems almost impossible to drown them out. During the third period, when the beet is maturing and sugar is being stored up less moisture must be applied. This means that there are really two times when the water can be applied to the best advantage, before the crop is put in, and when the beets have from six leaves until six weeks before maturity. During either period water can be put on as often as it is needed.

The plants themselves indicate a failing supply of moisture by the appearance of the foliage and are themselves a good guide to go by with the possible exception that beets in too wet soils will sometimes show signs of distress similar to beets suffering from a lack of moisture. But by taking the foliage indications in connection with an investigation of the soil conditions as regards moisture content to a depth of 5 or 6 feet a true insight into the condition of things can be obtained. Once familiar with the action of the soil as regards moisture, the plant itself is a never failing indicator. When the growth begins to slacken a bit, when the light green, normal color changes to a glossy, varnished purplish or bluish green, and when the normal crisp texture gives way to a flabbiness which is not overcome during the night, then the beets need water, and need it quickly. If allowed to go beyond this stage they again turn light green, but rapidly assume a yellow, sickly shade while a dead and dying outer leaf shows here and there.

The quick going back of beets once they show the need of water emphasizes the necessity of putting on the water as soon as the first signs of distress appear. Ten days to three weeks is sufficient time to check growth, depending to a large extent, of course, on the nature of the soil and the climatic conditions in the regulation of the movement of the moisture. For this reason, where there is a large area to cover with water, an early start should be made in order to insure reaching all the beets before they pass the critical stage and begin to actually suffer. It is far better to start a bit early on beets which are not actually in need of water than to delay so long that the last beets to be irrigated are actually suffering. Moreover when the character of the soil varies the aim should be to reach the poorer moisture-holding soils first.

In hot, dry, windy weather the going back will be more rapid than during cool, calm, foggy spells. Beets in sandy land will not suffer as much as those in heavier soil once the moisture content lessens to the danger point, but this point will be reached much more quickly in the sandy land.

Yellowing in spots on low land, which hold much water in winter, is brought about by the packing of the soil under the weight of the water, so that an environment is produced unfavorable to beet growth and favorable to excessive evaporation. Taught to receive water close at hand during its early growth when the bulk of it is gone, the plant seems incapable of seeking further and actually suffers for want of it. Moreover, in those wet spots root rot plays considerable havoc. The same thing holds true with beets grown in land which has been badly tramped by working down when too wet on top or a few inches underneath.

Beets which have gone until they are very yellow are beyond the stage where they will give the greatest returns from an application of water, but even then irrigation will pay. The sugar content, brought up by dry conditions, tends to go down but if several weeks of warm, sunny weather follow this will be regained.

The watering of beets drying and withering for lack of moisture will cause them to make a fresh start and make a satisfactory growth. While not wise to let matters reach that stage, still, if it does happen water can be applied to advantage. (This applies to beets which are *drying* for lack of water. The condition must not be confused with approaching maturity. In the former case the beet root will be dry, tough, easily bent and springy. When the beet is maturing the beets will be brittle, juicy, and snap when bent).

The action of water on maturing beets cannot always be foretold with accuracy. When there is quite a period of summer weather to follow, hot, dry and sunny, little good as well as little harm will follow the application of water. But when a heavy watering is given and is then followed by cool, moist, or simply cool weather, the beet tends to stop the formation of sugar and to turn to the production of seed. In most cases the irrigating of maturing or matured beets is to be condemned. While a gain in weight follows it is usually nothing more than water taken up by the plant. The sugar drops not in actual amount, apparently, but in its proportion to the weight of the beet, so that while as much sugar is present it appears to be less when the weight of the root is taken into account. If good maturing weather follows the application of water the excess moisture will be evaporated from the beet and soil, so that the sugar once more gains in proportion to the weight of the root. This seems to be due to an actual lessening of the weight of the root as the water is given off, or to sufficient new formation of sugar taking place in the plant's leaves, so that the sugar is increased enough to equal the final slight gain in the root. But should moist, cool weather follow application during maturity, it will work havoc by inducing seed formation. As soon as second growth starts the sugar content is drawn upon by the plant, and constantly decreases as growth continues. Water applied to mature beets during the hot summer weather tends to preserve them and assists in loosening the ground so that plowing out is attended with much less difficulty than otherwise. The water, however, will not increase the tonnage to any appreciable extent and may induce the seed formation with its attendant detrimental affect on the sugar content of the beet.

The yellowing of beet foliage is often a topic of much discussion among beet farmers, each maintaining his own particular views on the subject. The truth is that yellowing may be due to several causes, as:

(a) Too much moisture in the land in winter.
(b) Preparing the land when too wet.
(c) Maturity.
(d) Low spots receiving much seepage.
(e) Actual lack of moisture.
(f) Later effect of root rot ravages.
(g) Disease.

By combining an investigation of the moisture conditions in the soil, an examination of the beets and taking into account their age, a pretty close estimate of the cause can be determined. Beets four months old or over are ready to mature and the yellowing then will be normal. When the yellowing is abnormal the causes will show in the soil and in the beet. If on digging or boring down to the depth in which the plant is growing, the earth is found to be so dry that it cannot be molded in the hand or lacks the characteristic dark color imparted by water, if hardpans are encountered, or if an excess of standing water is present, then the presence of such undesirable conditions naturally will be the cause.

From the preliminary study of the soil conditions much of the season's methods regarding the probable need of water will be determined and the outline of the work can be quite definitely mapped out. Moreover, when the soil conditions are understood their influence on the plant's needs can be more closely watched and by this means larger and better crops can be produced at no greater expense.

Too much or too little water will result in reduced crops. With too little water the beet fails to gather the necessary food elements for best growth and in consequence remains dwarfed. With too great an amount the beet runs more to foliage and less to root where conditions are otherwise favorable, while the danger of a still greater supply lies in the waterlogging of the soil by driving out the air from around the roots. Roots breathe and therefore need air as well as moisture. Never of their own accord do they enter soil saturated with water. When too great a quantity of water is given it forces out the air and results in "killing" the soil.

Of times in irrigated sections there will be an actual saving in the use of water. Where plenty is at hand the temptation to use it often and in large quantities proves too strong. Let the grower learn to read the needs of his crop, then, and then only will there be no further temptation in this respect.

As to the amount of water to apply and the time to apply it, a study of local conditions again will prove the best guide. In general from 24 to 36 inches of water is needed to produce a full crop of beets, and all this should come within six or eight weeks previous to the harvest time. It may be stored in the soil during the winter and held by the usual methods of retaining crop moisture, or it may be put on at intervals. More than 12 inches of water in flooding at any one time is to be advised against, either to the growing crop or to the fallow soil. The amount at each time, however, must be varied to suit the conditions of soil and water supply. To provide the best conditions for the growth of the beet it is desirable to give the amount best suited to the plant's growth throughout the season, and to the depth within which the plant secures its food and water. Irrigations should in every case be sufficient to penetrate below the depth occupied by the plant, or to impervious layers if such exist. Where these are present the water must just moisten to the layers so that there will be no danger of saturating the soil. If an excess be used the plant will suffer until enough evaporates to permit the entrance of air into the soil, for neither air nor water should occupy the soil to the exclusion of the other—for longer than a very limited period at any rate. In open soils where the beet can go down almost unlimited distances the land should be thoroughly moistened to a depth of 8 or 10 feet by each irrigation.

The danger of oversaturating the soil is slight if an oversupply of water is put on lands with good drainage, which take water readily. Under these conditions the excess water is simply lost. This means greater expense in irrigating and also a leaching out of certain soluble plant foods. These plant foods are carried to depths beyond reach of the plant and lost. In clayey soils an excess of water will cause the beets to produce extensive foliage without a compensating amount of root. In other words the tonnage will be reduced.

Excessive irrigations promote evaporation by packing the soil and in a very few weeks after the water is put on there will actually be less moisture present than in soil not over-irrigated.

The size of the beet at the time the water is put on makes little difference. The larger the beet, the greater are its demands on the soil moisture and, consequently, the older the plant is the less leeway exists for delay in applying the water when it is needed. But if the amount of moisture falls below the plant's requirements water must be supplied no matter what the age of the plant is.

So many graduations occur of good, bad and indifferent methods of applying water as regards the time and amount that a careful study of this point is well worth while on the part of every beet grower. The whole aim is to provide a constant supply of moisture in the soil during the growing period of the beet, avoiding an excess on one side and a deficiency on the other with a diminishing amount as maturity approaches. Only by keeping the beet growing steadily from start to finish can the maximum returns be secured.

In all irrigation work the final crop desired is the point to keep in mind. High sugar content and heavy tonnage are opposed to each other and the maximum of each will not occur in the same beet. A happy medium must be obtained in order to produce a good sugar content in marketable beets, large enough to handle economically. If the tests are very high the weight will be low. On the other hand, when the tests of beets over four and one-half months old range low, a large overgrown beet will be found responsible. Find out which type of beet pays best to raise and then work accordingly.

Use of Alkali Waters. There is danger in using alkali waters for irrigation purposes unless a preliminary knowledge of their nature and effect upon the ground is understood.

Under the subject of alkali lands the nature of the different salts comprising alkali was taken up. It is these same salts carried in solution which gives to strong, salty-tasting waters the name of "alkali" waters.

In judging the value or danger of alkali streams or waters the sense of taste cannot be relied upon as an accurate guide. A chemical analysis of the water in question is necessary. This will determine the nature and amounts of salts present. To put water strongly charged with alkali on good land is in most instances an unwise course. But there are exceptions to this rule and if the land is of the proper nature and a few precautions are observed in using the water no harmful results will follow.

When the land is of a deep formation and takes water easily without waterlogging, or in other words if the water table is many feet from the surface (20 or more), and the soil itself is of a loose, open, more or less sandy nature, with layers of sand or gravel to provide good natural drainage and no impervious layers of clay or hardpan to hold the water back, then, and then only, may a grower consider the use of alkaline waters. By strongly alkaline I mean waters containing over forty grains per gallon of mineral content. If the land is heavy in nature, takes water but slowly, has a standing water table near the surface, has hard layers of clay or hardpan, or is in any way different from the broad conception given above, the land better not be irrigated with questionable waters.

It is not easy to give hard and fast rules as to what constitutes a good and a poor water for the nature of the salts plays a most important part. When they are of calcium or magnesia (the latter having an excess of calcium present with it) no objection can be offered to the use of the water. When on the other hand the bulk of the solids are alkalies—carbonate of soda, sodium chloride, and the like, to an amount greater than forty grains to the gallon, precaution advises against their continual use.

Should it become necessary to use saline water for temporary purposes, or as a general procedure under favorable conditions as given above, *copious* applications must be given, sufficient in fact to moisten the land to a depth of 10 feet or more each time. Should the application be temporary fresh water should be turned on as soon as it can be secured in order to flush out the salts deposited the first time. To prevent accumulations in the surface soil, by continual use of saline waters, through evaporation, frequent and copious irrigations are necessary. These will carry off the excess salts in the natural drainage of the country.

Any farmer can determine the value of his water for irrigation in a general way by evaporating a tablespoonful of the water in a clean, bright, silver spoon, using care to evaporate the water by steaming and not by boiling. The amount of residue will roughly determine the quantity of salts present in the water. Should there be but a thin film the water may be considered safe for use but should a definite crust remain it shows a high percentage of salts. If on the application of a little water these salts will redissolve it is fairly conclusive that they are alkalies. If such be the case it will be necessary to exercise care in the use of the water, and a chemical analysis to determine the exact status of the water should be made.

It is absolutely necessary in using alkali waters that they penetrate. Constant tests with a pointed steel probe several feet long, made of square steel one-fourth inch on a side and fitted with an adjustable cross-handle should be made. When the probe can be forced with ease into the ground, there the water has gone or will go if sufficient is used. By this method the presence of hardpans can be quickly determined.

When the irrigation is done by means of furrows it is advisable to use deep furrows and to give large amounts of water. Special care must be used to see that the water actually penetrates as deeply as it is supposed to go. As soon as the furrows dry out sufficiently to work after the irrigations they should be cultivated deeply and every attempt made to create and preserve a well fined mulch.

Land laid down by alkali streams will often be found valuable for agricultural purposes provided it is laid down by running water and not where pools of water are standing. The salts being soluble are carried off by the stream while the soil, having been subjected to the leaching power of the water, is freed of the salts. Unless other causes enter to recharge the land, little of an injurious nature will be left.

The Soil Auger. In addition to the soil probe described in the preceding paragraph, every farm should have a soil auger for use in determining the character of the soil at different depths. This does more efficient work than a shovel. It is a labor saver in time, and will reach depths otherwise inaccessible.

Two kinds of soil augers give satisfaction. The first is the King auger. This consists of a brass tube having an inside diameter of one inch. It is reënforced at the top with a collar so that blows can be struck to force the tool into the ground. The bottom is fitted with a bright tool-steel hollow point, tempered to a stone cutter's edge of ¾-in. bore. A heavy core fits loosely inside the tube, which, rimmed with a broad collar and topped with a handle, is used to drive the auger into the soil. The tube is driven down one foot at a time and the samples of soil can be taken out in sections and compared one with another. For use in dry soils and hardpans this is an especially fine instrument.

A cheaper implement consists in welding an ordinary 1½ or 2-inch carpenter's bit to the end of a five-foot ½ or ¾-inch round iron rod. An adjustable handle is then added, somewhat similar to that of a posthole digger. To go to deeper depths other sections of rod can be made to screw on to the first one, being fitted with matched holes at the joining with a pin to go through so that in turning the rod the parts will neither unscrew nor tighten up so that they cannot be easily separated. In moist soil this will do excellent work. For dry soil it needs a piece of brass tubing fitted around the bit, after grinding down all but the lower end so that the tube and bit do not exceed the original size of the bit. In very hard, dry soils the tool will not equal the King auger. By pouring a little water into such holes the work will often be greatly facilitated when the examination is simply to determine the character of the layers of soil, and not for the purpose of determining the moisture.

Other types of augers are on the market. Most of them will do excellent work.

Fertilizing the Sugar Beet.

What the beet uses.—In order to arrive at the needs of the beet as regards plant foods an analysis of the different parts of the plant is given in pounds per hundred pounds of leaves, crowns and crownless roots.

	Nitrogen.	Potash.	Phosphoric Acid.	Lime.	Total Ash.
Leaves	0.64	1.09	0.114	0.41	4.30
Crowns	0.43	0.45	0.120	0.05	1.35
Crownless roots	0.28	0.36	0.112	0.03	0.84

This table shows several things, prominent among which is the small amount of ash (plant foods) removed from the land in the part sold to the mill. The leaves and crowns contain 87 per cent of the total substances taken up by the plant in feeding.

Expressed in pounds of mineral matter removed, a crop of 36 tons (counting both tops and roots) will take out:

	Roots (20 tons).	Tops (16 tons).	Total.
Potash	152	235	387
Soda	24	199	223
Lime	16	208	224
Magnesia	24	172	196
Phosphoric acid	36	80	116
Nitrogen	60	113	173

Other yields will withdraw plant foods in proportion to these amounts as they are greater or less than 36 tons in weight.

Use of Commercial Fertilizers.—If $10 worth of fertilizer will increase the profits of the beet crop to a greater extent, obviously it pays to fertilize. But if no actual gain in money follows the use of fertilizers the amount expended on them is only thrown away.

At present there is no method by which the needs of the soil as regards fertilizers can be determined except by actually trying out the fertilizers in the field. Chemical analyses or other laboratory methods fail at this point, but a trial in the field will give actual results. Each farmer must do this for himself on each particular type of soil represented on his farm.

Soil is derived from rocks and its character will, therefore, be largely determined by the nature of the rocks from which it was formed and by the agency which brought about the disintegration—rock weathering, wind, stream, volcano or glacier. A study of this question is a problem too deep for the average farmer as it involves time as well as a knowledge of geology, physics and chemistry. Moreover, the final results would be doubtful gains from a practical standpoint. In any soil the elements which are apt to be found wanting are nitrogen, phosphoric acid, potash and lime, either singly or in combination. Which is needed, if any, to increase the beet crop can best be determined by laying off plats in the beet field which will contain, when planted, twelve rows of beets 88 feet long. This is equal to one twenty-fifth of an acre when the rows are 20 inches apart. The plats should be placed side by side, the fertilizer sowed on each just before planting, and each plat carefully marked with corner stakes.

The following plats should be run:

		Amount — Per acre, pounds.	Amount — Per plat, pounds.
1.	Nitrate of soda (before planting)	200	8
2.	Nitrate of soda (before summer irrigation, if one is given, or when the beets have eight leaves if dependence is placed on the natural rainfall	200	8
3.	Superphosphate	300	12
4.	Sulphate of potash	200	8
5.	Nitrate of soda	200	8
	Superphosphate	300	12
	Sulphate of potash	200	8
6.	Nitrate of soda	400	16
	Superphosphate	600	24
	Sulphate of potash	400	16
7.	No fertilizer	..	..

The plats must be prepared, planted and subsequently handled exactly alike.

When the crop is ripe sections of a couple of rows about 200 feet each are dug or plowed up from different parts of each plat and a total of 400 or more well-preserved, unmutilated, representative beets are selected, topped carefully and weighed.

On comparing the figures, if the total weight of the beets in plat No. 5 is greater than in No. 7, it is evident that fertilizing paid. Then if No. 1 and No. 3 give greater returns than No. 7, while No. 4 is about the same, it is plain that the nitrate of soda and the superphosphate are what produced the increase, and are the ingredients needed.

A comparison of No. 5 and No. 6 will broadly determine the amounts needed, while No. 1 and No. 2 will show the best time for applying the nitrate of soda if this is to be used.

This simple experiment will determine very closely the needs of the plants.

But the increase in yield must be sufficient to more than offset the cost of the fertilizer, or at any rate to equal it. Suppose the fertilizer in No. 5 costs $10 and in No. 6 $20, and the yield of the plats, calculated to an acre (figuring 20,000 beets to the acre), is increased in No. 5 by 25 per cent over the normal yield in No. 7 and by 30 per cent in No. 6. Then if $5.50 per ton is received for the beets, and No. 7 goes 12 tons, we shall have:

No. 7 will yield 12 tons worth	$66.00
No. 5 will yield 15 tons worth	82.50
No. 6 will yield 16 tons worth	88.00

In round numbers the fertilizer would cost $10 in No. 5. It returned $16.50, consequently it paid. But the fertilizer in No. 6 cost $20 and thus only returned a profit of $2 over the expenditure. Hence we may conclude that No. 5 is the best amount to use.

Then, again, if the plats receiving a single kind of fertilizer show that the benefit was from only one or two then the useless ones can be omitted and the returns will be increased that much more.

Lime may be tried by running an eighth plat or by putting a strip crosswise of the other seven so that all receive a lime application with the fertilizers. By determining the yields from the two parts of the plats separately, the need of lime on the soil can be determined both as regards a plant food and as a means of bettering the mechanical condition of the soil.

The use of fertilizers will often pay where they are not at present being used. The author has increased the yields of new light loam soil from 8 to 13 tons per acre simply by an application of nitrate of soda put on before the first summer irrigation. The plants had nine or ten leaves at the time. Applied earlier it did not give as good results. This meant an increase in profits of $26 for an expenditure of $5.

As to the forms of fertilizer to apply. When a complete fertilizer is needed probably nitrate of soda and tankage for the nitrogen, superphosphate for the phosphoric acid, and sulphate of potash for the potash will fulfill all requirements. In general when the land requires potash it can be supplied in: (a) 75 lbs. of sulphate of potash; (b) 75 lbs. of muriate of potash, or (c) 300 lbs. of Kainite. Of these the first one is best as the second has a tendency to make watery beets.

If phosphoric acid is needed it can be obtained from: (a) 200 lbs. of acid phosphate; (b) 175 lbs. of dissolved bone, or (c) 250 lbs. of bone meal. Of these, the first will usually prove to be the most desirable. Of the first two, one-half the quantity put on will become available the first year, and the other half the second. The third will become only slowly available the first year.

These amounts are based on the usual content of commercial fertilizers.

Green Manure Crops.—Green manure crops are crops grown on the land and turned under green for the purpose of improving soil conditions. With certain crops, such as alfalfa, it is sometimes possible to take off a crop or two, but the majority of them are turned under without harvesting any part.

Green manure crops accomplish several objects. Their main use, however, is to replace humus and nitrogen in the soil. Two classes of green manure crops are recognized—one with nitrogen-gathering power, and the other without. Plants such as beans, peas, vetches, burr clover, horsebeans, velvet beans, cowpeas and clovers are nitrogen-gatherers, that is they are able to gain their nitrogen from sources other than the natural supply in the soil. It is gained by means of microscopic bacteria which develop in the knob-like excresences or nodules found on the roots of such plants. Plants which do not have the capacity to gather their nitrogen by means of these bacteria are far less desirable green manure crops. Of course such nitrogen as they appropriate from the soil is returned when the plant is plowed under, but there is no increase. For most purposes one of the plants possessing the nitrogen-gathering property—a legume in other words—should always be selected for green manure purposes.

Most soils are abundantly supplied with the bacteria needed by the leguminous plant. Once in a while, however, an exception occurs and it is then necessary to introduce the required form of bacteria. Whether or not bacteria are needed can be quickly told by examining the roots of the growing plants upon which they are desired. The plants should be carefully dug out—never pulled—and the clinging soil gently washed off in a stream of water. If on examination of the legume, which has been taken up so carefully that there was no chance of scraping off the nodules, none are found, it is a sign that the land needs bacteria. The small roots should be examined as well as the long main ones.

Several ways are open for gaining the needed bacteria. The use of half a load of soil from fields where the plants show the nodules can be resorted to, or else a supply of the bacteria in bottles can be secured from the United States Department of Agriculture free of charge, with full directions for using.

Nitrogen is one of the most necessary elements for plant growth and its gain can be figured in dollars and cents.

Humus is partly decayed animal or vegetable matter. A green manure is not humus at the time it is turned under. Various agencies of decay and disintegration must work upon this mass of green stuff and break down its composition. When the process has reached the point where there is no resemblance to the original material it is humus. Continued beyond this point it becomes nothing but ashes. Humus is the black, earthy material without definite form which gives soils their dark tint on being moistened.

Humus plays a very important part in soil fertility as it has the ability to keep the soil in a mellow, rich and spongy condition, thereby preventing crusting and cracking. It permits free circulation of air in the soil, gathers and retains all moisture which falls, binds loose sandy soils, and overcomes the close, retentiveness of clays. Finally, in breaking down, it liberates plant food.

The value of a green manure crop depends on the amount of humus and nitrogen which can be obtained from it. This is based on the amount of green growth produced, found by weighing the crop, and by the plant's ability to collect nitrogen from the air, which is determined by chemical analysis. For most practical purposes the legume yielding the most tonnage will prove the best manure crop. Just what plant to use will depend on local conditions, one plant doing better in some sections than others. For most localities the vetch, Canadian field pea or alfalfa will probably be found satisfactory.

The following table gives an idea of the different yields and the value of the crop in dollars and cents, based on its nitrogen content. It means that if the nitrogen had to be purchased in the open market, in the form of ammonium nitrate, nitrate of soda, or the like, the cost would be in the neighborhood of the sum set opposite each crop.

TABLE SHOWING THE VALUE OF GREEN MANURE CROPS.

	Nitrogen 100 lbs. green tops.	Yield per acre in lbs.		Nitrogen per acre.	Value of Nitrogen.
		Tops.	Roots.	Lbs.	
Common vetch	0.62	58,715	9,677	407.5	$81.50
Hairy vetch	0.53	68,365	12,705	273.0	54.60
Horsebean	0.48	37,812	17,545	244.2	48.84
Burr clover	0.51	54,873	1,075	285.0	57.00
Field pea	0.70	24,000	1,044	167.0	33.40
Fenugreek	0.53	25,711	2,134	144.5	28.90
Red clover	0.53	*15,000	....	79.5	16.00
Young alfalfa	0.72	*11,000	....	79.2	16.00
Crimson clover	0.43	*14,000	....	60.2	12.00
Cow pea	0.27	*18,000	....	48.6	10.00
White lupine	0.44	*25,000	....	110.0	22.00
Yellow lupine	0.51	*15,000	....	76.5	16.00
Orchrus pea	0.58	*75,000	....	435.0	87.00
Tangier pea	0.51	*40,000	....	204.0	41.00
Scarlet vetch	0.60	*50,000	....	300.0	60.00

Some of these were eastern grown and some western. The yields cannot be accepted as absolute because one crop will succeed better in one locality than another.

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*Tops and roots.

Only by experimenting with the different crops can definite figures be obtained. The nitrogen, too, will vary, although probably not enough to take into account.

Green manuring ranks ahead of commercial fertilizing in importance. It will not, however, replace anything except nitrogen and humus. When potash and phosphoric acid are lacking, they must be replaced by means of commercial fertilizers.

Three possible ways present themselves for growing green manures for use in connection with the best crop. The first is to plant early in the fall or late in summer in order to gain enough growth in the fall and winter to permit plowing under in the spring sufficiently in advance of the beet crop that the mass of green stuff may be well rotted. A second way is to grow only as fall crops, plowing under before the winter storms set in. This is especially advisable under conditions existing in the East. The third method is to utilize the ground for one regular growing season, putting in the crop in the spring. The climatic conditions of each locality will determine the method. If there is a choice, either of the first two ways is preferable as no time is then lost from the regular crops and numerous green manure crops can be grown in the rotation.

The greatest inconvenience met with in green manures will come at the time of plowing under the growth if it is very heavy and tall. Fall and winter growths will usually not be great enough to give trouble in this way. But by first dragging the stuff down and then plowing, or by using a chain in front of the coulter the work will progress satisfactorily. The new style double-disk plow which has just been put on the market is especially well adapted to this work. The first disk cuts half the depth desired and turns it well under. The second disk cuts the rest of the furrow, turns it over and places it on top of the first. These plows will go down to a depth of 16 inches with ordinary horse power. Plowing under deeply is advised in order to put the green stuff down where it will do the most good and where it will receive the most moisture.

In order to hasten decay plenty of water is necessary. Where irrigation facilities are available the water should immediately be turned onto the land after the crop is put under. Then following the drying out of the soil after the irrigation a light harrowing should be given as soon as it can be put on the land. This should not go deep enough to bring the green stuff up. Warm, moist conditions will greatly assist decaying.

When the water supply is limited, green manuring is something of a problem as it is unwise to turn a big mass of green stuff under if a drouth is liable to follow, as this stuff will keep the land open and may fail to rot in time to permit working the land for the next crop. Of course with a summer crop this is not such a difficult proposition. For use under such conditions a crop should be selected which has the greatest nitrogen-gathering capacity and at the same time makes a thick, fine-textured, fibrous growth. Vetch is a good example. Moreover, it may be well to consider the advisability of cutting the first crop for hay—providing a hay plant is chosen—then letting it continue its growth until enough more has formed to pay for turning under. Or, instead of cutting for hay, there is always the choice of pasturing the land until it is fed down to the required amount.

Green manuring is a subject receiving much attention in the more arid sections, and is certainly a subject well worth all the time and thought spent upon it.

Barnyard and Stable Manure.—Stable or barnyard manure must be applied with caution to the beet crop. On light, sandy soils little harm will result from applications up to 10 tons to the acre put directly on the land just previous to a beet crop. On beet soils naturally rich and heavy, the large applications of manure will result in a forcing of the growth so that a large, watery, distorted, ungainly beet is the result. Under such circumstances the manure can be applied to the best advantage on the rotation crop. Placed on the land in the fall for spring beets the ill effects will be much less but even then more than a very light dressing is apt to result in damage to the beets.

Manure is very valuable when used in the proper manner but its effects on the beet crop will be enhanced if put on the year before. Based on analyses, the value of common manure is about $2.34 a ton for the plant foods it contains at prevailing prices for the ingredients. This does not take into account the humus value of the manure and its beneficial action in improving the texture of soils. In general, manure contains 10 pounds of nitrogen, 10 pounds of potash, and 6 pounds of phosphoric acid. It is, therefore, rather weak in potash and phosphoric acid. When these elements are lacking in the soil, commercial fertilizers containing them must supplement the manure. The greatest gain comes from the nitrogen content and the humus value of the manure. These are sufficient to more than pay the cost of hauling it on to the land. When the manure must be purchased the price to be paid will depend largely on the need of the soil as regards the applications of humifying material. The value of the manure in this respect must be judged by the need of each particular soil and whether the manure will prove a cheap and more effective method than a green manure crop. The plant foods are worth over $2 a ton and a price equal to this may be paid before the humus value need be considered.

The care and disposal of the manure when removed from the stables and yards determines to a large extent its value. Proper care at this stage will greatly enhance its value. The manure should either be protected at the barn or else spread right in the field when fresh. The latter way increases the efficiency of the manure and lessens the cost of handling.

Mill Waste Water.—The use of mill waste water is very advantageous to the land as it carries all the impurities contained in the beets. The analyses of mill waste water are variable, depending on what particular method of sugar extraction is predominating in the mill, on the distance from the mill where it is received, on what is dumped into it at the mill (i. e., press cake), and on the average composition of the beets going through the mill. In general, however, it is very rich in fertilizing elements. Two typical analyses showed a variation of from 2,584 to 3,088 solid parts per million of water. Of this 50 per cent was sludges and organic matter and about 20 per cent was lime. The high percentage of sludges and organic matter shows the extremely high fertilizing value of the water. In 12 inches of irrigation of potash, 3 pounds of nitrogen, and over 100 pounds of other salts.

Calcium carbonate is soluble only to a very slight extent in water, and its action will, therefore, be slow in most soils. Hence, the danger of burning out the humus of soils by the use of even large quantities of mill lime is practically nil. I have used it at the rate of 200 tons (86 tons actual calcium oxide) and produced no apparent ill effects in the soil. The crop produced was slightly in excess of that on the unlimed land. Lime is beneficial in an indirect way, more than as a direct plant food. When any of the following conditions exist, to the extent of requiring a corrective, the application of some form of lime is certain to prove profitable.

(a) Lime is a splendid correcter of the poor physical condition of soils. With loose, sandy, blowy soils it binds the coarse sand grains together; with heavy, impervious soils it holds the clay particles apart. In each case it enhances the chances of storing and retaining moisture and makes both soils much easier to work. Implements are much easier to direct and the land breaks up much more readily. Crusting and cracking is never as great on limed soils as on unlimed soils of the same nature.

(b) Lime neutralizes the acids of the soil which when present makes them "sour" so that many plants fail to make a good growth in them.

(c) It prevents the formation of the more insoluble compounds of phosphoric acid with alumina and iron, taking up the phosphoric acid to itself, thus putting it into a form more available to the plant. With the various potash salts it sets potash free, so that it is much more ready for the use of the crop. In other words it changes the unavailable or only slightly available forms into forms immediately useful to the plant.

(d) Compounds of iron and other substances of a possible injurious nature are rendered harmless.

(e) The spread of certain rots is retarded by the lime.

(f) By producing conditions better suited to rapid decay lime hastens the decomposition of vegetable matter, first into humus, and later humus into plant foods. One of the attendant results is the production of nitrogen water, a total of 7,000 pounds of solid matter is put on the land of which about 1,400 is lime.

The lime is probably combined with certain of the organic bodies so that it does not actively attack the soil, being neutralized to a great extent by the acid of the beets. Only a few parts of carbonate or hydroxide forms of lime are present. This means that the heavy liming which lands adjacent to the mill receive, is not detrimental, and instead of the lime acting as an active agent in causing the natural plant foods stored in the soil to become available, the great fertility comes from the material in the water which is put on.

The heavy crops of beets taken off such lands, even after being grown for a number of consecutive years, is evidence of the value of the water. The author has in mind a field of 35 acres which has been in beets every year for the past eleven. The last two years it has averaged 23 and 25 tons, respectively, to the acre. And others can call to mind cases of a like nature. While this may be an exception it is true that of the land needing irrigation, the land which receives the mill waste water is greatly benefited by it.

Mill Waste Lime.—The sugar beet delights in a well limed soil. This is true of other plants such as onions, spinach, lettuce, parsnips, and also of such fruits as apples, pears, peaches, plums and cherries. Of the field crops the clover, alfalfa, beans, peas and vetch require large amounts of lime. For these crops a heavy liming is beneficial and the lime from the sugar mill can be well utilized for the purpose, whether it be run on the ground in the irrigation water or hauled out and spread by hand.

The benefits from liming are positive and numerous, the results obtained being proportionate to the amount of calcium present. The usual average lime cake as it comes from the mill contains 80 per cent of its dry matter in the form of lime, with a good proportion of the three main elements of plant food—nitrogen, phosphoric acid and potash—as well as other organic salts. The amount of moisture present will determine the actual lime. This usually figures at from 40 to 50 per cent so that in a ton of material there will be about 800 pounds of calcium oxide, 15 pounds of phosphorus and 1 pound so that lime indirectly gains nitrogen for the plant. This characteristic is especially valuable on heavy soils or when green manure crops are turned under.

The use of lime on many soils is a necessity, and the value of a supply of sugar mill lime is great for not only is the necessary liming effect secured but much valuable plant food is put on with the lime.

Crop Rotation.—As the land becomes less and less productive, new methods must be taken up to stop the decrease and gradually rebuild the soil up to its former state of productiveness. The reduced yields are usually the result of constantly growing one crop, such as corn, wheat, oats or the like. Whether the reason for the lesser yields is due to the actual reduction of the plant foods in the soil, the removal of these foods faster than they become available, to the presence of microscopic parasitic plants in the soil, or to the actual giving off of poisonous substances by the plants themselves is of little importance to the farmer. He wants to get the yields and knowledge of the methods which will produce those yields. Scientific information is necessary, but the busy farmer has no time to delve as deeply into the study of the causes as a proper investigation entails.

The use of commercial fertilizers, summer fallowing and crop rotation have been tried out and found to offer the desired solution. Of these methods, crop rotation—the growing of alternating crops—has been found of greatest importance. On strong land, rotation will hold off the day when fertilizers must be applied for a number of years, the length depending upon the crop grown, the time the land has been under cultivation, and the natural strength of the soil in the first place. Rotation without fertilization is away ahead of fertilization without rotation. This is especially true when the practice of green manuring is introduced in the rotation. Of course, neither rotation nor green manuring will replace phosphoric acid or potash when there is a notable deficiency of these, but when the supply is fair, rotation and green manuring will greatly prolong the period for receiving the greatest good from whatever is present.

That the sugar beet holds a high place in crop rotation is now a matter of record. The old-time prejudice against it is giving away as the observing farmers note the great increase of crops which follow the beet crop. American farmers, in their headlong rush to plant, cultivate, harvest and market, have neglected their bookkeeping, and it is difficult to give definite figures which show just what the effect is on crops following beets. A few examples selected at random show an increase of crops following the beets over the yield secured on land not in beets as follows: Oats, 80 per cent; barley, 73 per cent; hay, 66 per cent; wheat, 80 per cent; barley, 57 per cent; wheat, 75 per cent.

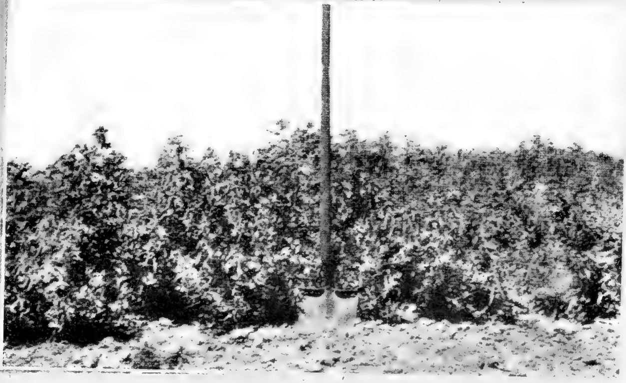
German figures carefully compiled from an average of thirty-five farms show a very remarkable increase:

	Before beet culture.	After beet culture.	Increase, lbs.	Per cent.
Wheat	1,848	2,292	444	24
Rye	1,456	1,672	216	15
Barley	1,672	2,094	422	25
Oats	1,355	1,918	563	42
Peas	985	1,834	849	86
Potatoes	6,716	13,500	6,874	102

How the Beet Benefits the Soil.—It would be surprising if good yields were not secured after the beet crop. The thorough preparation of the soil for the beets and the subsequent excellent care given it are reflected in the better physical condition of the soil and the suppression of the weeds. Both of these benefits extend over to the next crop.

The beet is a deep-rooting plant and brings up plant foods from the stores deep down in the soil, and through the rotting of the tops places these in the surface soil within reach of shallow-rooted crops. They are also in a form more available for the plants—predigested, so to speak.

The rootlets of the beet, in decaying, form first humus and then plant food. They also leave little channels running several feet into the ground, thus permitting drainage and aeration to a far greater extent than is otherwise possible. Roots of future crops will follow these passages and thereby secure more moisture and reach greater stores of plant food. It has been estimated that one ton of humus is put down into the soil by these rootlets. And it is put deeply, where it will do the most good.



BARLEY HAY AFTER BEETS, 5.5 TONS PER ACRE.
PEAS FOLLOWING BEETS.
OAT HAY AFTER BEETS, 3.5 TONS PER ACRE.

The land is plowed deeper than usual by five to eight inches and just so much more land becomes available for future crops. Most crops derive their nutriment from within the space prepared by the plow. Moreover, in the usual work the plowings are repeated to one depth. This results in the formation of a plow pan which the deep plowing for the beets breaks up.

When the beets are plowed out the land is given a deep subsoiling.

There is nothing miraculous or difficult to understand about this. The benefits are positive and easy to trace. The source of income from the sugar beet is by no means the total benefit derived. The beneficial effect on the soil can be seen in following crops, often until the third year after. The soft, mellow condition of the soil, the freedom from weeds, and the actual increase in the size and yield of the subsequent crops, point out the beneficial action of the beet. In short, the beet offers wide opportunity for the systematic and economic rotation of crops.

To the farmer who is not already raising beets a trial will convince him of the truth of these remarks. Fifty acres, or, if that is too much, twenty-five, or ten, or even five put into beets will quickly furnish proof if the plowing, seeding and cultivating is done right. Another year, when the old stand-bys are planted on this place—grain. potatoes, corn, alfalfa, or whatever the main crop is—the greater yield and greater ease in handling the land will prove an agreeable surprise. Incidentally and probably more important, the life of the land will be prolonged, thereby indicating the possibility of securing a guarantee of lifelong returns, not only to the grower, but to his children.

Planning the Rotation.—To obtain the greatest returns from the land a definite rotation of crops should be planned. This should be mapped out in accordance with the crop which constitutes the main source of income. For all farms near a sugar mill which have the right kind of soil, the sugar beet will eventually prove the principal crop. Rotations should, therefore, be planned with reference to this crop. The one which will return the greatest yield of beets is the one which will be preferred. Such a scheme will prove that the land is being kept up in the best possible shape.

In general, it has been found that the sugar beet will follow potatoes, beans, peas or beets to good advantage, while it does remarkably well after alfalfa.

On the other hand, barley, wheat, oats and flax will follow the beet crop to advantage. Corn does not start off quite as well, but eventually it proves fully equal to that grown elsewhere.

In most regions the rotation of beets, grain and potatoes is generally followed. Corn is sometimes used in place of the grain, and beans instead of the potatoes.

Any rotation which leaves the land mellow, full of humus, and free from weeds and stubble is a good one. Preferably beets should not follow alfalfa or corn, as the roots and stubble prove very vexatious because of their tendency to clod up and drag the implement teeth. In cultivating young beets many are apt to be destroyed by this stuff clinging to the cultivator and being dragged along the row unnoticed.

As a rule, crops requiring deep plowing should follow beets, while those not needing it, or at least not so particular in this respect, should precede them.

On most ranches and farms the present scheme of more or less haphazard rotation can, with profit, be brought down to a systematic basis. Having determined the crops which it is possible to grow at a profit on the land in question, a scheme can be evolved which will cover both the ranch and soil needs. Let us, for example, figure on a farm which has 640 acres of good tillable land, suitable for alfalfa, beets, peas, beans, potatoes and grain. Such soils are common in the sugar beet districts, as a soil which will raise anyone of the first five will usually raise the others. In order to make the farm self-sustaining, all the hay and grain needed for feeding must be produced at home. Moreover, the use of some green manure or leguminous crop must be included to renovate the soil—a matter taken up at some length under "Green Manuring." For most districts, alfalfa, beans and peas will fulfill all the requirements of the soil as regards nitrogen-gathering. When the soil is deficient in humus, or where the humus burns out rapidly, provision must be made for returning it to the soil. This can be accomplished most easily and quickly by sowing with the grain crop some form of a green manure crop which can be left to make its growth after the grain is off and then plowed under. Or, if ample water is available from rainfall or irrigation, after the grain is off, the land can be moistened and then prepared for the reception of the green manure crop. With the warm weather present in the summer time the crop will make a quick growth and will be ready for plowing under in the fall in time to permit it to rot during the winter. In the rotation which we will consider, clover can take the place of alfalfa, peas the place of beans, and oats, wheat or barley can constitute the grain.

After selecting the crops, which we will consider to be alfalfa, barley, beets and potatoes, the next step will be the planning of the order in which these crops are to be raised. In the majority of cases it will be found better to leave the alfalfa in for two years. By this method some hay can be obtained the first year, and considerable the second. The last crop should be left and plowed under. By this means humus is replaced in the soil. Alfalfa is lending itself as a most desirable crop for sugar beet districts, as the crops of beets which follow it are record-breakers. Moreover, alfalfa does especially well on land treated with the mill waste line, carried on either in the water or by carting out and spreading by hand. In order to facilitate the killing of alfalfa before putting in the beet crop—something which can be done with comparative ease, as the alfalfa will not be old enough to possess roots of the size and toughness of old alfalfa fields—potatoes or beans should follow the alfalfa. Potatoes do very well on this land and, as they do not tax the soil, they leave it in excellent shape for the beet crop. As they are planted in wide rows, the frequent and thorough cultivation which they require can be easily done and will at the same time kill the alfalfa shoots which may come up. Beets can follow the alfalfa, but more or less trouble will be experienced in cultivating. If, however, the method for killing the alfalfa, as outlined under "Preparation of the Soil for Irrigation," is followed, beets may follow the alfalfa with comparative ease. Following the potatoes comes the beet crop for one or two years. Grain follows the beets, part being cut for hay and part for grain.

When commercial fertilizers are required, they will go on the crop which needs them most. The manure, when used, will go on the land to be in potatoes or beets, being put on the previous fall, or on the grain crop.

Our rotation for each field will, therefore, consist of:

First year	beets
Second year	beets
Third year	grain
Fourth year	alfalfa
Fifth year	alfalfa
Sixth year	potatoes

Several fields should be devoted to the rotation, and to follow out the scheme to the best advantage the ranch should be divided into fields as nearly of the same size as possible. The ideal condition is level, uniform land under irrigation. But as this happy ideal is seldom met with, each farmer must do the best he can with what he has. This scheme would call for six fields. The ranch would therefore be divided into six parts. Each part or field would then receive the treatment according to the scheme, each field starting in at a different point of the rotation the first year; that is, field No. 1 would have beets the first year, beets the second year and so on down the list. But field No. 2 would omit the first year's beets, starting in with second year and then continue. Field No. 3 would start in with the third year's crop—grain—and then continue, and so on until all the fields were accounted for. Summed up, it would give:

Field.	1st Year.	2d Year.	3d Year.	4th Year.	5th Year.	6th Year.
1	beets	beets	grain	alfalfa	alfalfa	potatoes
2	beets	grain	alfalfa	alfalfa	potatoes	beets
3	grain	alfalfa	alfalfa	potatoes	beets	beets
4	alfalfa	alfalfa	potatoes	beets	beets	grain
5	alfalfa	potatoes	beets	beets	grain	alfalfa
6	potatoes	beets	beets	grain	alfalfa	alfalfa

By this means one-third of the ranch is in beets each year, one-sixth in barley or other grain, one-sixth in one-year alfalfa, one-sixth in second year alfalfa and one-sixth in potatoes. Congestion of work is prevented and provision is made for the principal crop to be beets, while the land is left in good shape for the succeeding crop.

This example is simply a rough guide to indicate the scheme of figuring out rotations. It considers only one-sixth the land in grain. If more is wanted, some variation will be required from the plan given above. In such a case a rotation might prove feasible consisting of:

First year.................beets
Second year...............grain, followed by green manure crop
Third year..................potatoes
Fourth year...............beans

In planning the rotations, those fields which are to have the same crops at the start should be brought together to facilitate handling.

By adopting a system making the sugar beet the major crop and regulating the crops which are to follow, the producing capacity of any farm can be held at the maximum, while the danger of congesting the work at some one time of the year will be effectually done away with.

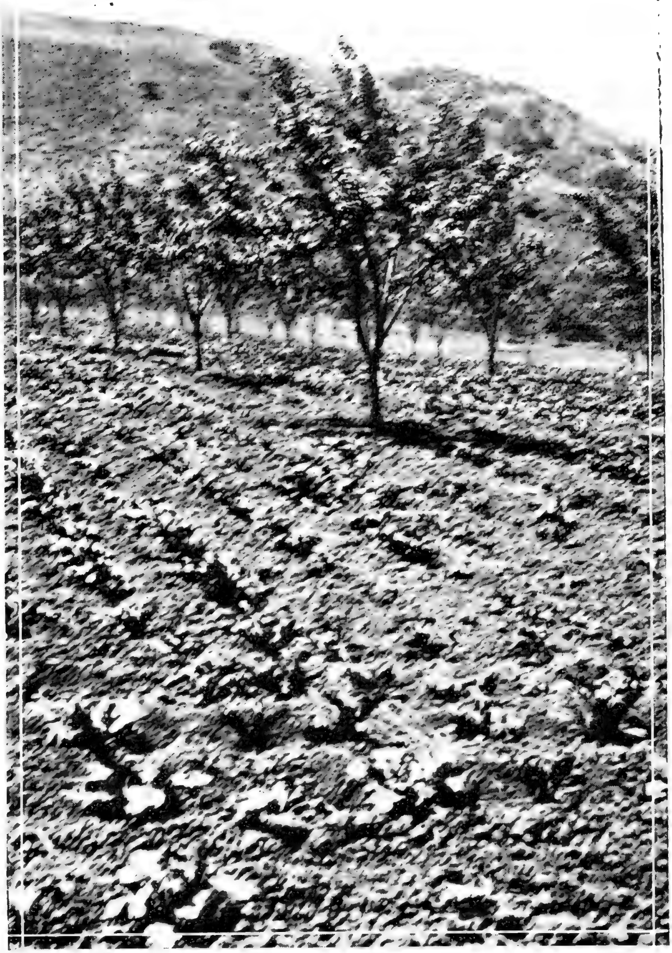
Sugar Beets in Orchards. The three principles of successful orcharding are pruning, cultivation and fertilization. To this must be added spraying, when insect or fungus foes are troublesome.

The questions of pruning and fertilizing have been given much attention and methods have been evolved which amply cover most conditions.

The main question is one of cultivation and this is a very important subject. For the proper growth of the tree, careful handling of the land is absolutely necessary. Pick up any authority on orcharding, and invariably he will advise deep, thorough plowing, preferably for one, two or three years before the trees are set out. After the trees are in, the order of the day is rather deep plowing and cultivation just as soon as the trees have been set.

Thorough breaking up of the land accomplishes four things. It makes plant food available, it preserves the loss of moisture through evaporation, it holds the weeds in check and it permits air to circulate in the soil. Anything that will produce a condition of perfect tilth with no drain on the trees is to be recommended. Alfalfa, clover or grain have been suggested for use in the orchard but they are not desirable. The difficulty in keeping the crop where it belongs, and the impracticability of giving them proper attention while growing are factors against their general use, to say nothing of the large amount of plant foods removed by them.

One of the finest crops for use in orchards is the sugar beet. Four rows among old trees and eight rows between



SUGAR BEETS IN ORCHARDS.

the rows of young trees not over three years old will accomplish wonders. In the first place the land is deeply plowed for the beets, 10 to 16 inches, and the thorough handling required by them is reflected in the trees. Then careful hoeing and cultivating throughout the season is a direct benefit to the trees. The moisture is preserved by the maintenance of a surface mulch. As the beets grow they shade the ground and prevent evaporation. The consequent result of such treatment is to cause the roots of the fruit trees to go deeper, the land is left in much better shape, and the tiny rootlets of the beets help to break up the deeper layers of soil. When the beets are dug these small roots return humus to the soil while the tops return not only humus but a large amount of available plant food.

And finally when the crop is harvested there is the possibility of a snug return from the sale of the beets.

Only one possible objection can be raised to sugar beets in orchards and that is the question of a moisture supply. Both the beets and fruit trees are heavy drawers of water, and to mature both to advantage an ample supply of moisture must always be at hand, with the exception of the ripening period in the fall.

Watsonville, a great apple growing district of California regularly practices this method, and finds the sugar beet a valuable adjunct even in full bearing orchards.

Mechanical Labor Savers. No effort should be spared to utilize all mechanical contrivances possible, such as blockers in connection with thinning, toppers, elevators and diggers—all of which are described from time to time in the agricultural papers, sugar journals, government and state publications.

Elevators and mechanical toppers are beyond the reach of the small farmer, but there are many ingenious little devices he can use, such as hooks for use on seeders or heavy land to pull the seeder down into the ground, crust breakers, and cultivator appliances.

The selection of proper wagons is important. While these must conform to the unloading platforms it is well to get away from nets and use, as far as possible, self-dumping wagons.

All beet tools should be heavy, well constructed and serviceable. Care both in first selection and in subsequent protection of implements is well worth the taking. Leaving tools out in all kinds of weather is a very bad policy. Not only do stiff, rusty tools create a larger draft for the stock but their life is shortened 50 per cent. A decent tool shed will soon pay for itself.

The Factory Agriculturist. The factory agriculturist is paid by the management to produce the beets. As far as possible his training, previous record, capacity for work and capabilities are looked into before he is employed.

Because of the fact that he is well fitted to handle the difficult questions of plant growth, the grower should get in close touch with him. If the agriculturist is a new man, unfamiliar with the local conditions he will be only too glad to accept the statements of men fitted by long residence and successful experience, as to the methods which have produced the best results. Later, after becoming acquainted with local conditions, he may be able to introduce improvements over the old way which will result to the mutual advantage of all concerned.

The interests of the agriculturist and of the grower are one—the production of the beets. To be thoroughly successful each must recognize the viewpoint of the other. The agriculturist can help the grower to a great extent, especially in suggesting remedies for unfavorable conditions, such as the gradually lessened production brought about by over or under-irrigation, alkalies, seepage water, improper rotations, lack of plant foods, insect and fungous pests, and so forth. The choice of the seed to plant properly comes under his jurisdiction. In short the training of the agriculturist along the lines of soil physics, plant pathology and plant physiology fit him to properly solve the problems incident to plant growth.

The true agriculturist is growing beets, not for this year alone, nor for next year, but for many years to come. The million-dollar investment, more or less, that a sugar mill represents, cannot be made a paying investment in a single season or in two seasons. Only after long years of bountiful harvests can the investment be considered a success. And the agriculturists's duty is to bring this about as far as possible. His suggestions, therefore, are based on the future, rather than on the present. Too often losing sight of this point of view, the grower blames the agriculturist for adopting policies which may not wholly favor the grower. This point should not be overlooked in judging the agriculturist's actions.

Therefore, every grower should feel free to use the services and experiences of the agriculturist for by so doing the interests of both will be furthered to a great extent.

Sugar Beet Culture in the Salt River Valley.

The soil conditions in Arizona are such that no land that has not previously been in cultivation should be selected for sugar beet culture. The land that has proved to be best suited to this crop is the loose, soft land that at some time previous has been cultivated to alfalfa. The soil in general is not impregnated with sufficient humus unless alfalfa has been grown or material of a humus nature plowed into it. There are sediment soils in the lowlands along the rivers or irrigation ditches that grow excellent sugar beets, but it is advisable to select an old alfalfa field for growing the crop.

Experiments have been carried on in all different soils in the valley, and according to the topographical map of the government, the Glendale Loess and the Maricope sandy loams have by far demonstrated their adaptability over all other classes of soils. This land is found in the vicinity of Glendale, Kyrene, Mesa and the Buckeye country. It can be readily distinguished from the undesirable adobe and sandy soils.

The planting season extends from the first of November to the middle of February. Continued experience has shown that the land should be plowed early and allowed to lay fallow for a month or more before preparation. The land should be plowed 8 to 10 inches in depth and if the beets are continued on the land for a period of three or four years, which is possible and also advisable in this valley, the second or third year a deep tilling machine should be used, plowing the land from 14 to 16 inches deep.

About two or three weeks before planting the land should be well levelled, borders thrown up and flooded evenly. Care should be taken not to keep the water on the land too long or to allow it to back up at the head or waste ditches. When dry enough to work, the borders should be split and levelled down and the field worked up with any of the approved cultivators. Discing or spring-toothing does not give the good results obtained in some other places. The land permits working quite wet and forms an excellent seed bed by using the harrow and ordinary board float. The practice is in all cases to work the land with the tools referred to frequently enough to bring it into garden shape on the surface.

Planting is done with the regular beet drills, in rows 18 inches apart. The climatic conditions are such that most excellent stands are procured from any of the standard seeds.

Cultivation should begin as soon as the beets can be discerned plainly in the rows. In most cases the field should be well rolled before the cultivation begins. Knives, discs or spiders should be the cultivator equipment for the first cultivation. All later cultivations should be given with the chisels and duck feet. The standard makes of 4-row cultivators have proved the best in all cases.

After the first cultivation the beets should be thinned, leaving a single beet every 8 to 10 inches in the row. Labor for this work is very easily procured in the valley, the charges being from $4.50 to $5 per acre. Very little hoeing is necessary if the thinning is well done and the expense therefore is materially lessened, as after the thinning the cultivator if properly adjusted, will keep the field clean of grass and weeds until laid by.

After the first flooding irrigation for the preparation of the seed bed, only two irrigations are necessary. The first of these two irrigations is given in the latter part of March and the other in May or June, according to the time the field is to be harvested. The cross-field irrigation ditches should not be farther than 40 rods apart, and in the irrigation of the rows, every row should be well furrowed out and the water conducted so that as little flooding as possible is done. Flooding is a bad feature as the ground bakes around the plants and also endangers scalding.

The harvesting and delivery of the beets starts in May and June and continues until August. On account of the temperature this must be a very rapid operation. As before stated there is ample labor available, and for topping, piling and loading into wagons the charge is from $7 to $9 per acre.

The yield on good land will run as high as 27 tons per acre, and the harvest is over in plenty of time to plant a crop of cowpeas, sorghum or milo maize on the same piece of ground after the beets are removed, thereby giving the man who is willing to work the opportunity of producing two crops on the same piece of land the same year.

Conclusion to Cultural Work. In general, the averages of tonnage and quality of sugar beet production are far below what they should be. Examples of high yields in every section indicate the possibility of raising the average far above of what it is. In 1910 the average for the whole United States was 9.73 tons per acre. This means that the profit is not as great as it should be. In fact, cost of production and receipts are not very far removed. The beet crop requires proper handling and care to do its best and is by all means a crop for intensive farming. Certain rules have been worked out which will aid the grower in producing his crop, but only by unceasing study of local methods can the greatest ultimate profits be secured from his land. It is not always possible for every man to attain the highest yields of any section, because of the difference in his land or because of unfavorable location, but it is a fact that with the majority of farmers more knowledge concerning the crop's needs and greater attention to the details which will result in fulfilling those needs will bring about increased profits.

Sugar beet growing demands that the work be done on time. Planting, cultivation, thinning, irrigating and harvesting cannot be delayed without detriment to the crop. But on the other hand no crop responds more freely or promptly, or manifests its appreciation of proper attention more quickly, than does the sugar beet.

Further development of the beet sugar industry will doubtless result in a greater tonnage and higher sugar content and purity, but much of this must be brought about by the appreciation and practice of better farming methods on the part of the grower. The aim should be to make the land pay increased profits rather than to look to the mill for a higher price. At the present time the farmer receives for a ton of beets nearly one-half the market value of the sugar in those beets. The other half must pay operating expenses, interest on money invested, risks, depreciation of mill and the profit. Unless the market price of sugar goes up, the chances of the farmer receiving more money from the mill is doubtful in most sections. But an improvement, however, can well be looked for in the soil of his fields.

Throughout this discussion of the culture of the sugar beet, I believe the fact which stands out most prominently is the need for every farmer to *know his soil*. Only by a study of each field by itself can the proper principles of crop handling be worked out. This can easily be done by each individual farmer and in the determination of the character of his soil will come the solution of most of the cultural problems. The greatest factor in this study is a good preparatory course in common sense.

Should work spring up in this study which is beyond the scope of the farmer—such as alkali determinations—the State Experiment Stations and the United States Department of Agriculture stand ready to help. As the farmer pays his share of the taxes to support these institutions he is entitled to his share of their work.

CHAPTER II.

Feeding By-products.

Pulp. Beet pulp is the beet slices after the sugar has been extracted, and these constitute in weight about 85 per cent of the total beets worked. These cuttings are run out into a big silo or else shipped fresh. As cattle feed the pulp is very valuable. Even to this day there are many sections which do not fully appreciate this important food. For sheep, hogs and cattle it proves a cheap and desirable feed. For dairy cows it acts as a conditioning food, thus increasing the milk flow.

Beet pulp is put out in three forms—wet, siloed and dry. The siloed is more or less moist, but a great deal of the water present in fresh pulp drains off down the silo drainage system. All are desirable foods. The wet pulp varies in analysis but in general consists of:

	Per cent.
Water	88.93
Nitrogenous matter	.88
Digestible carbohydrates	6.70
Indigestible carbohydrates	2.40
Fat	.07
Ash	1.02
Dry matter	10.67

Siloed pulp loses mostly excess water. It experiences some changes through butyric and lactic fermentation so that it gains in dry matter.

Its average composition is:

	Per cent.
Water	88.01
Nitrogenous matter	1.13
Digestible carbohydrates	6.85
Indigestible carbohydrates	2.90
Fat	.11
Ash	1.00
Dry matter	11.99

Dry pulp is simply fresh pulp with the bulk of the water removed by means of some mechanical heating method. When dried it is unaltered in composition—simply contains the same ingredients of the fresh pulp, only in larger proportion. In general it contains:

	Per cent.
Water	7 -10
Nitrogenous matter	7 - 8
Digestible carbohydrates	55 -60
Indigestible carbohydrates	18 -20
Fat	.5- 1
Ash	10 -12
Dry matter	90 -92

The selling price of dried pulp varies greatly, ranging from $12 to $25 a ton. Often the pulp is mixed with a portion of the waste molasses or with some other edible or nutritious foods. From the standpoint of the feeding value it is worth eight times as much as siloed pulp and ten times as much as fresh pulp. When the savings in freight is taken into account it is worth still more.

Pulp commands various prices. The rate is by no means uniform and is seldom based on the feeding value of the pulp. From the standpoint of feeding value fresh pulp is worth from $1 to $2.50 a ton. The feeding value is largely determined by the character and amount of the feed given with the pulp, the kind of stock which is fed (age, weight, condition, etc.), the initial cost of the feeders and the value of the finished product. Just as these factors vary from one year to another in different sections so will the value of the pulp vary. From analysis the pulp is worth at least $1.29 a ton. Compared with corn silage containing 70 per cent water it is worth half as much. If the pulp is pressed so that it contains 70 per cent water its value is equal. The cattle, however, will eat twice as much of the pulp.

Pulp forms a nutritious and wholesome, although a rather poorly balanced ration.

Pulp is fed either for fattening purposes or as a maintenance ration.

Of the two methods the lesser amount of pulp will be used under the second way of feeding. Pulp fed in small quantities to dairy cows (20 to 40 pounds) will increase the flow of milk. It will not affect the butter fat. The pulp will not impart any unpleasant taste to milk, cheese or butter when used in this quantity. Care must be exercised in starting in to feed pulp. Small quantities should be fed at first and gradually increased until the desired amount is being given. Experiments run with dairy cattle at the Utah experiment station showed that 24 pounds of beet pulp per day per cow for six weeks in addition to the hay and grain gave a better weekly gain than twelve pounds of sugar beets. With the pulp the average weekly yield of milk was 131 pounds. With beets it was 127.4.

In fact, on a small place of 40 or 50 acres of tillable land, and a little pasture, the use of beet pulp and alfalfa, where it can be grown, with a small ration of grain will make dairying a very profitable industry. By rotating the land, one-half in beets and one-half in alfalfa for three years and then alternating, profit can be secured from the crops and work provided for the men. The beets themselves will prove profitable, the alfalfa will produce hay and prepare the land for the beets, while the pulp secured will prove a most desirable feed. Fifteen to twenty head of cows means a steady income of $150 to $200 a month. The use of the manure secured and the effects of the crops on the land will result in an actual increase in fertility—a welcome contrast to the hard usage most land receives.

For fattening cattle, beet pulp can be fed with profit either in a large or a small way. On small farms a few head can be successfully fattened.

On a large scale four factors determine profit in pulp feeding to fatten cattle, or any other stock, for that matter:

(a) The cost of the feed.
(b) The cost of the feeders.
(c) Feeding must be complete in three months.
(d) The selling price.

Feeding Beet Pulp. To obtain the greatest returns from the use of beet pulp it should never constitute the total ration. This applies to both fattening and maintaining stock. Feeders can be fattened on pulp alone, but the dangers of weak, broken-down backs and kidney troubles are ever present and the stock must be marketed as soon as ready. Moreover, while a ration of pulp alone will put more flesh on a cow or steer that is already in good condition, it will not fatten poor stock unless used

FEEDING CATTLE ON BEET PULP IN CALIFORNIA.

in connection with something else. Chemical analysis shows that only a small per cent of the fresh pulp is food, 90 per cent being water. But cattle certainly make gains on it. This is due to the fact that it is a succulent feed and by increasing the digestive capacity of the animal and providing certain conditioning properties it fits the animal to make better use of its hay and grain. Cattle fed entirely on beet pulp cannot be put back on pasture. They must then be sold to the butcher.

The kind of feed to give with the pulp for fattening depends on the local supply. The use of oil meal, corn, alfalfa or barley hay, field peas, barley, or roughage, such as straw, dried beet leaves or coarse hay, is determined by the amount at hand and the value. Consequently the method varies with different sections. Ten to 12 pounds of alfalfa seems to be the best combination. Later this may be supplemented with 5 pounds of corn, or 2 to 5 pounds of oil meal. The character of the feed, too, depends on the object sought, whether quick finishing or partial maintenance and partial fattening.

At first the cattle must be starved to the pulp, for they do not always take to it readily. This will require four or five days, but once they do take to it they will eat it with relish. In general it may be said that the daily ration of pulp should amount to about 150 to 180 pounds of fresh pulp, or 80 to 110 pounds of siloed pulp, with 10 to 15 pounds of roughage and 2 to 5 pounds of oil meal or grain for cattle averaging 1,000 pounds. This means that steers totaling 100,000 pounds (say 100 head) will require 7.5 tons of pulp, one-half ton of roughage, and from 200 to 500 pounds of grain a day.

It is usually the plan to chop the roughage or hay and mix with the pulp, but this is a wasteful practice. The most successful way is to feed separately, as the hay ferments very easily when mixed with the pulp and large quantities have to be thrown out. The sour pulp left contaminates the new supply and causes it to spoil rapidly. The untouched stuff litters up the yards and causes an unwholesome condition.

When men and teams are available the putting of the pulp in the feed boxes every few hours will result in a saving of material, as the stock will then keep it eaten up clean.

The hay should be fed from stalls or scattered on the ground from the wagon. In dry weather the latter way is preferable, as it gives the weaker stock an equal chance while feeding.

Siloing. Pulp is easy to silo, as it protects itself whereever it is in quantity by the formation of a hard, shell-like covering 3 to 6 inches deep. This protects the pulp beneath. To be handled most economically the pulp should be put in large piles as the outer coating is best discarded. There, therefore, will be less waste from the big piles. Pulp differs from other ensilage as corn, clover, pea, etc., in that no care is required to exclude the air. The beet pulp takes care of itself in either the silo or when merely thrown in a pile.

When the amount of pulp fed is small the piling method will answer. But for storing any quantity for any length of time, the construction of a suitable silo will prove a profitable investment.

The location of the silo is important. In curing, pulp gives off a vast amount of water—from two-thirds to four-fifths of the original weight. For this reason land having quick and easy drainage is necessary. When this does not occur naturally it must be artificially provided. Water standing in a silo gives water logged, soggy, imperfectly cured pulp. This is difficult to handle, has a tendency to sour quickly and is distasteful to the stock. Silos should, where possible, be placed above the feeding pens. The pulp can then be carried by hand cars to the feed boxes, or if wagons are used to transport it the haul will be easier, especially when the roads are muddy. This means a saving in time and money.

In building the silo the best kind to make is one built in the ground by excavating a long, shallow hole and lining with inch planks on the sides, and two inch on the bottoms. Pulp silos differ from those for corn, alfalfa, etc., in that provision must be made for great lateral swelling power. This strain is so great that only earth walls will withstand it. The silo can be built in the ground or on it. In the latter case walls of earth are drawn up around the silo. For most situations the removal of the soil for use in building the sides will prove most economical, the pulp being stored where the soil is taken out. Board or plank silos built above ground will not stand the pressure, even when reinforced with iron bands.

It is best to make the silo wide and shallow rather than deep and narrow so that the wagons can be loaded in the silo and then driven out without too great an expenditure of energy. When the silo is too small to back the wagon into it, the extra work in shoveling from a deep silo will not compensate for the saving in space.

The floor of a silo is the important part. It must be so laid that the drainage is good, the flooring solid, and shoveling easy. If the soil is gravel the drainage will take care of itself. But when the soil is heavy artificial drainage must be provided. Two-inch planks set at a slight angle to permit the excess water to drain off at one side and far enough apart to prevent clogging, will do nicely. From the side where the planks discharge, a ditch or pipe can be laid to the nearest slough.

As the value of pulp becomes more generally recognized the sugar companies are building big silos for storing and then shipping out as needed by the feeder. Siloed pulp is worth more than fresh pulp. I have in mind a factory which sells fresh pulp for 25 cents a ton and siloed for 65 cents, yet it takes five tons of fresh to make one of siloed, due to the very large size of the silo and the great pressing given much of the pulp in it.

Feeding on a Large Scale. Pulp feeding on a large scale has been proved a profitable venture. There is a good market for all pulp-fed stock, as the flesh is tender though firm, and can be cut off the carcass almost before the meat is cold. In other words it does not require ripening. This appeals to the trade and pulp-fed meat always commands top-notch prices and often a premium in addition. Moreover, the stock fattens six weeks earlier when fed on pulp.

To properly feed cattle (the usual stock considered) a number of factors must be carefully studied out. Among these are:

(a) The feeders, their source, kind, condition, age and cost.
(b) A dry, well drained yard with ample corral room and railroad facilities.
(c) An ample supply of pulp and roughage or other feed.
(d) The market.

Manifestly the buying and selling price must be far enough apart to permit feeding and transportation costs and to allow a fair profit. It is usually cheaper to bring the cattle to the pulp, i. e., in the vicinity of the sugar mill, than to transport the heavy pulp to the cattle. By shipping, cattle can be sent many hundreds of miles, and finished off to advantage. The kind and condition of the feeders is an important point. Profitable feeding means that the cattle (the stock most generally used, the same thing would apply to sheep or hogs, only in a different degree) must be finished in 120 days for light stock and 150 days for heavy. The feeding, of course, will keep up as long as the pulp lasts, usually six to eight months. New stock will be brought in to take the place of that sent to the block. To make the greatest gain stockmen favor animals ranging from three to five years of age. Less food is utilized for growing purposes and the stock can put on fat rapidly. For this reason two-year-olds do not make the gains that older animals do. Animals with large, well sprung ribs, broad backs and small necks and shoulders—in other words, the best beef type—should be selected. These make greater gains in weight and command better prices. Durhams are a class of cattle well fitted for fattening. Even should there be but a dash of Durham present in grade stock it will show in the better fattening of the animal.

The proper feeding facilities are very important. To feed to the best advantage the animals must be confined. It is then possible to gauge the amount of food required, and there is less loss. The labor item is also reduced. Sufficient corrals should be available so that there will be a few extra ones for use in wet weather. It is very important that the corrals be kept dry and the proper selection of soil is necessary. Pulp-fed cattle secrete great quantities of urine, which, combined with the water from the pulp, means that in soils other than those of a very sandy or gravelly nature, muddy conditions are bound to result. This has been the cause of failure in many an instance. Young bullocks are fastidious. They dislike sloppy, wet conditions. Old cows and steers are not so particular, but even with them fattening will be delayed.

The yards should be near enough to a main line of railroad so that there is but a short drive, and at the same time far enough away so that passing trains will not disturb the cattle. This is especially necessary with range stock, as being unaccustomed to trains, barking dogs, a continual stream of people, or much shooting, quiet and peace are essential to rapid gains. At the same time the yards should be on a spur track so that the pulp can be shipped direct to them. When it is necessary or desirable to store a portion of the pulp, a properly constructed silo is a valuable requisite. This should be located with reference to the feeding scheme, and preferably should go on high ground so that the pulp can be carried by gravity cars to the feeding pens, as described under "Siloing."

Corrals of fairly large size are desirable, for instance five acres in each, as they permit moving the feed boxes around when the ground becomes sloppy. It also keeps the cattle from crowding by giving them room for feeding or basking. In this connection it might be well to draw attention to dehorning, which is an advantageous method to follow with feeders.

By means of a network of wooden or iron track cars can be used to carry the food to the cattle. Any method of loading or unloading which will save time and labor will mean increased profits.

Trees for shade and windbreaks are advisable. Where they do not occur naturally they should be planted, using kinds best adapted to the section. The protection and comfort for the cattle will be returned in the faster rate of fattening.

The troughs for feeding should be wide, fairly shallow and long so that the cattle can feed from both sides without interfering with one another. A convenient size is 18 inches deep, 3 feet wide, and 10 feet long, made with ample drainage to take off the excess water. This can be done by boring holes or leaving spaces between the planks, or if the troughs are wanted for some other purpose a hole can be bored in one end and through which the excess water can be poured. When the troughs are wanted elsewhere this can be stopped up and all made watertight. The feed boxes should be made as light as possible to facilitate moving and yet solid enough to prevent the cattle moving them around.

When the boxes are to remain permanently they can be made as long as wanted with a platform on one side for the cattle to stand on while feeding. The track can run along the other side and the pulp be put in very easily.

A constant supply of roughage must be on hand. If this can be grown in the immediate vicinity, so much the better, but if it must be hauled provision must be made to insure a constant supply on hand at all times. It is a wise policy to contract for the hay in advance.

Beet pulp feeding has made money for every man who has studied his conditions. With the prospect of a steady market, and the increasing necessity of raising stall fed cattle to meet much of the demand, the value of the beet pulp for feeding is bound to advance. It is an investment well worth investigating.

Preserving Pulp. The odor emanating from pulp silos is often so offensive that means for stopping it are desirable. Common salt at the rate of four pounds to the ton of pulp put on every 6-inch layer has been recommended and found good. The use of certain lactic ferments to put in the silos is coming to the front, but uptodate they have not had sufficient trial in this country to show their value.

Molasses. Molasses is the final residuum of the beet juice after it has gone through all the sugar extraction processes. It still contains a large quantity of sugar, and all the salts and other impurities which were present in the beet juice. It also contains the unextracted substances which are used in the process. The molasses has a bitter and disagreeable taste and is unfit for human consumption, but is well worth considering as a stock food. Mixed with ground dry feeds and other rations it has given excellent results. It is quite generally fed in Germany. The molasses must not be fed alone or in large quantities because of its purging effect. When fed without mixing with dry feeds it should be diluted with two times its volume of water. In Europe it is fed mixed with a kind of mull from the top of moss, mixed while hot, and sold as a patent food. As a recommendation for use in this country mix 20 pounds of molasses with 100 pounds of chopped hay or straw. After getting used to it cows will eat 20 pounds of this with 15 pounds of cottonseed or linseed meal, or 20 pounds of wheat bran. When first feeding only small quantities of molasses should be given, gradually increasing the amount until the full ration is being fed. At the start only one-fourth the amount should be fed. Molasses is of great value to all kinds of stock, including horses, if not fed in too large amounts, as it has certain conditioning properties. For work stock the molasses can be sprinkled on the hay either normal or diluted, at a trial rate of two pounds per day.

Beet Tops. Beet tops are an important addition to the list of stock foods. They can be fed fresh, dried, siloed and either alone or in combination. They give a rare flavor and color to pork and beef. Stock fattened on tops command highest prices at killing time.

Mechanically-dried tops contain about 10 per cent of water, and the feeding value is about nine times that of fresh tops. The field dried tops are about equal in feeding value, ton for ton, to first quality hay. It takes about four tons of fresh tops to make one of dry.

The tops will equal from 20 to 40 per cent of the total weight of the plant—the usual average being 25 per cent. That is for every 12-ton crop of roots, there will be three tons of tops. In order to arrive at the value of the tops for feeding, whether this be done on the home ranch or on purchased tops, knowledge of the relation of tops produced to roots is necessary. If the value of first-class hay is $10 per ton, the fresh tops will be worth $2.50, as they lose three-fourths of their weight in drying in the field, since dry tops are equal to hay. If the yield of roots is sixteen tons, the yield of tops (if they are 25 per cent of the whole) will be four tons of fresh tops or one ton of dried tops. If taken up and fed these will be worth $10 per ton, or $10 per acre when dry. The fresh tops will be worth $2.50 per ton or $10 per acre.

Beet tops should be fed preferably in the field. The reason for this is pointed out under "Correct Topping of Beets." If taken off all the fertilizing ingredients are lost, unless every bit of the manure made is returned to the land. Feeding on the land is not so bad, although even in this case about one-fifth the value is lost, as the manure returns 80 to 85 per cent. Figuring in this way the following table is interesting:

A crop of roots of	Gives tops	Ingredients returned in manure at 80%	Ingredients Lost.
8 tons	2 tons	1.6 tons	.4 tons
12 tons	3 tons	2.4 tons	.6 tons
16 tons	4 tons	3.2 tons	.8 tons

But as 25 to 50 per cent of the tops will be trampled in, the actual loss in feeding in the field is only from 400 to 800 pounds, of which 90 per cent is water. The tops for feeding in the field—less 25 per cent trampled under—are therefore worth:

From an 8 ton crop of roots...........$3.75 per acre.
From a 12 ton crop of roots........... 5.62½ per acre.
From a 16 ton crop of roots........... 7.50 per acre.

When selling tops for feeding it is well to contract by the acre. It is sometimes a question how much stock an acre will support and again there is no assurancre that all cattle will be put on which the land can carry. Acre rates will prove more satisfactory to both buyer and seller than a per head pasturage rate. An important provision should be inserted which requires that all cattle be removed from the land as soon as serious rains come, as their tramping over the muddy ground will result in puddling the soil, something difficult to overcome in future working. Cattle on the fields will trample down levees and ditch banks and even tramp down the land if dry. These things must be taken into account when considering the pasturing of cattle on beet tops.

The gain on beet tops depends, as in feeding pulp, on the age, condition and kind of stock at the start, the length of time fed, and the location of the fields as regards noise and disturbances. An actual experiment with ranch steers and Mexican cows (the cows were poor feeding stock) gave after being on tops 75 days an increase of 170½ pounds for the steers and 118 pounds for the cows. They sold for 5¼ and 4¼ cents on the hoof with no deduction for shrinkage. The original cost was 4¼ and 3¼ cents respectively. The net profit was the value of the fat stock over the thin—one cent a pound, and the value of the increase in weight. When sold the steers averaged 1,283 and the cows 832 pounds. The stock received nothing but beet tops and such green stuff as they could pick up along the ditch banks.

With reasonable care there is no danger in feeding beet tops. They should not be fed moldy. Care must also be exercised when bringing cattle from dry feed to the tops. If fed too much at first they scour badly and fattening will be set back several weeks. In a large field it will pay to herd the stock on the portion which has been harvested long enough to permit the tops to wither and wilt, as there is no danger of scouring when the tops have reached this stage. In this way, too, there is less loss, for stock will leave dry tops for fresh ones if they can get at them.

The greatest danger is from choking and moldy beets. For choking a piece of stiff rubber hose three feet long should be always at hand to be used in forcing a lodged top on down through the animal's throat. If a choking animal is not promptly attended to it will strangle to death. When a beet top becomes stuck the affected animal will hunt some shrub or low spot to hide. Such places should be constantly watched. After the stock has been on tops for three or four days the avaricious greed they show at first slackens, and the danger of choking is then slight.

Moldy beets are the outcome of moist, warm weather. Dry, or nearly dry, tops will not become readily affected. Tops showing mold should not be fed. While any moldy food is bad, moldy tops are especially so.

Beet tops make a good feed and will prove an extra source of income from the land. The more land put in beets the greater will be the return from this source. Personally, the author believes the income derived from the beets more than offsets the damage to the land, provided the stock is not left on after the land becomes wet. The amount of fertility lost is hardly enough to take into account, if proper methods of green manuring, fertilizing and crop rotation are being followed. Of course, when the land is in need of humus, plowing the tops under green is most advisable, but after a few treatments of this kind, the tops can be used to advantage for stock feed.

CHAPTER III.

Beet Troubles.

The discussion of beet troubles will prove more formidable in these pages than their real occurrence in the field. The beet is singularly free from insect and fungus pests, so that only at rare intervals is the application of any remedy necessary. When a trouble does appear, however, a quick, correct diagnosis and the speedy application of a remedy will often mean insurance against damage. For this reason the different general troubles are taken up here. Many of these are purely local, others are more or less general, while some appear only at more or less infrequent intervals. Probably no section is troubled by all of them.

Insect Control.—The direct control of insects depends on their method and way of feeding. For forms which feed on the top of the beet, spraying is employed to a large extent. It is beyond the scope of this work to do more than point out the best method to employ. Insects gain their food by either sucking (as plant lice, leaf hoppers, etc.) or by actually eating the tissues of the plant (as caterpillars, leaf miners and many beetles). To kill the former, a spray must be employed which will come in actual contact with the insect. Sprays for this purpose are of an oily nature and kill by forming a film over the insect, thereby shutting out the air and causing the insect to suffocate to death.

For insects which gain their food by eating parts of the plant, poison for them can be put on where they are in the habit of feeding, so that when the insect feeds it will take in the poison with its food. Sprays for this purpose should contain very active poisons which will stick to the plant during wet spells of weather.

For sucking insects the contact poison, as it is called, usually employed is kerosene emulsion. It is made of:

½ pound whale-oil soap.
2 gallons kerosene.
1 gallon water.

The water is brought to a boil and the soap is dissolved in it. Then this mixture is removed from the fire and the kerosene added, the whole then being churned together until of the consistency of thick cream. The easiest way to do this is to pour it into the spray tank and pump it back into itself under high pressure for a few minutes.

This constitutes the stock solution. For use against the insects it is diluted at the rate of one part of stock solution to fifteen parts of water. The formula given will, therefore, be sufficient for one ordinary 50-gallon barrel of spray.

It is absolutely necessary that the spray be thoroughly prepared, so that there will be no free kerosene present. This would tend to be injurious to the plants.

For insects which chew their food, arsenate of lead is at the head of the list. It is easy to mix and spray, is effective, and sticks on once it is dry, in spite of numerous rains. The usual rate of application is three to five pounds to a barrel of water (50 gallons).

Clean culture around the fields will go far toward reducing insect pests. The removal of rubbish piles, the cleaning out of fence corners and lines, the picking up of old pieces of board and other trash, and the removal of weeds will prevent the wintering over of many adults, with a consequent reduction of insects. Cleanliness around the fields is worth more attention than it usually receives. And the beauty of such a course is that it benefits the farm where it is practiced, irrespective of neighbors' neglect.

The pasturing of turkeys or poultry on the beet fields until the young plants begin to peep through will go far toward ridding the land of many insect pests.

Fungus Control.—Bordeaux mixture is the usual remedy for fungus troubles. It consists of a combination of bluestone (copper sulphate), lime and water. It is usually made of five pounds of bluestone and six pounds of lime to 50 gallons of water. The bluestone is dissolved in 25 gallons of water. Unslaked lime is used for the lime part. The required amount of lime is slaked with just enough water to moisten it, care being taken not to drown it. When thoroughly slaked, enough water is added to bring the total up to 25 gallons. For spraying, the two are run together into the spray tank through strainers, and thoroughly stirred together.

In spraying, either for insects or fungi, the material should be put on when it will dry. It will then be quite resistant to rains. Any spray outfit is satisfactory which throws a fine, mist-like spray under pressure. The nozzle is important in this connection. The Bordeaux and Vermoral are both standards.

With a growing plant like the beet it is necessary to repeat the sprayings as often as new growth appears, and to protect all parts it is necessary that the spraying be very thorough. In fact, the degree of success attained by the spray will be directly determined by the thoroughness of the work.

Combined Insect and Fungus Control.—This is accomplished by using three to five pounds of arsenate of lead in Bordeaux mixture, and spraying both at once. It can only be utilized against insects which chew their food.

When any general insect or fungus trouble is apt to appear, it is good policy to spray the crop when it gets above ground and to repeat the spraying at intervals of two or three weeks. This is especially applicable to sections suffering from leaf-spot. By putting on a combined fungicide and insecticide, as just described, many insects will be destroyed with the fungi, and vice versa.

In using combined sprays they should be mixed only when needed for immediate use.

Insect Troubles.—It would be a long list to name all the insects which feed on the beet. For general purposes the following only are of sufficient importance to warrant special notice:

Insects Affecting the Beet Foliage.—A host of insects occur here, for the succulent green leaves offer an attractive addition to insect diet. Blister beetles, both the striped one, or old-fashioned potato beetle *(Diabrotica vittata),* one-half inch long, with black and yellow stripes, and the cucumber beetle *(Diabroctica 12—punctata)*, same length, but green in color, with twelve black spots on the back, are voracious feeders. These are familiar to all.

Plant bugs of various kinds, leaf hoppers and webworms, of which the beet webworm *(Loxostege stictacalis)* is the most important, feed on the beet. The latter is a pale, yellowish-green caterpillar, spotted with black points, from each of which a hair arises. When full grown they are three-quarters of an inch long. They are the young of a moth with fringed wings. They live under a web which they spin for protective purposes, on the crown leaves, or underside of old leaves.

Woolly bears *(Spilosoma virginica)*—large hairy caterpillars—are familiar feeders.

The beet army-worm *(Caradrina exigua)* also feeds on the tops, as does the zebra caterpillar.

The irregular channels often seen in beet leaves are caused by the migrations of a tiny slug working between the two surfaces of the leaf. It is the young of a fly *(Pegoya vicina)*, resembling the common housefly, only one-half as large. It is more interesting than serious.

Thrips, tiny insects with featherylike wings, do some damage to the leaves but are seldom serious. They differ from the ones just mentioned in that they require a contact poison.

The flea beetle, several families of which are usually represented, is the worst pest of the beet top. The beetles have strong, well-developed hind legs, with which they propel themselves forward with great leaps, similar to the action of a flea. They skeletonize the leaf of the beet by eating the pulp out from between the veins.

The red spider *(Tetraynchus bimaculatus)* is easy to recognize. They are tiny mites, visible on the underside of the leaf as red specks. They spin a protective web. Contact poisons will assist in reducing them.

Plant lice are known to all. Any contact poison will hold them down. The ladybirds (red beetles) are the greatest factor in keeping them down, and in ordinary seasons will be the only control required.

Insects Affecting the Roots.—Few insects attack the roots of the beet, which is indeed fortunate, as this is the real marketable part. The root louse *(woolly aphis)* and wireworms are the two worst pests. These will be taken up in detail with one or two other insects demanding more than passing notice.

The Woolly Aphis (Pemphigus betae).—The woolly aphis is closely related to the same insect on the roots of apple trees. It lives in the soil on the fine roots of the beet, drawing its nourishment from the sap. As a result the beet suffers, and if the insect is present in any number, it will be dwarfed and much reduced in weight.

The presence of the insect is easy to determine from the small, white, woolly-like masses which, like mold, surround the insect for protection. This gives the insect its name. Within this protective covering is the insect, a pale, lemon-yellow or whitish pear-shaped body of all sizes up to one-eighth inch in length. The legs are black and the insect is equipped with a beak through which it sucks its food.

Early in the spring the insect flies into the beet fields and settles down. They breed very fast, no winged forms being present until the numbers have multiplied to such an extent that crowding results. Then a brood of winged forms will be produced which fly off to other parts of the field. In the fall, on the approach of cold weather, or after the beets are harvested, winged forms also appear which leave the field and seek winter quarters.

The insect will live on either dock *(Rumex)*, pigweed or lambs quarters *(Chenopodium)*, or on beets. If stray beets remain in the field they will winter over on these. If there are no beets the insects will come from the dock or lambs quarters in the spring.

Prevention is the sole method of control. As the insects are under the soil on the beets there is no cheap remedy which will reach them. Irrigation is of no use, other than to encourage the beet to renewed effort to withstand the insect attack. The removal of other plants upon which the insects feed is the main source of control. Dock and lambs quarters should never be permitted in the fields, in the ditches, or along the fence lines. While only a general campaign, involving all growers, will give anything like complete freedom from the aphis, the killing of the weeds will result in a greater freedom on that particular place, as well as prolong the time before the insects appear.

To successfully kill dock it should be either dug up or else cut off below the crown. Chopping it off at the surface will merely result in the throwing up of new growth.

Beet Blight or Curly Top.—The trouble known by these names is a condition produced by the feeding of a small leaf hopper on the beet. For many years the condition has appeared to a greater or less extent in many of the semi-arid sections. It is unknown in humid regions, so far as the author can learn. It baffled all attempts at solution until recently, when Dr. E. D. Ball of the Utah Experiment Station definitely located the cause in the feeding of a small leaf hopper (*Eutettix tenella*). The author has verified Dr. Ball's conclusions and worked out quite a little concerning the insect in California. As the subject is by no means thoroughly understood at the present time, a fairly complete description may not be out of place.

The insect which produces the trouble is about one-eighth inch long, whitish or cream in color, and has a hump-backed or round-shouldered appearance when at rest, because of the position of the wings. Unless one is familiar with leaf hoppers he would be apt to overlook this one, as it is not at all conspicuous, and, being shy, rapidly flies ahead of all comers. It is commonly known as "white fly" when numerous enough to attract attention.

The damage is done by the insects feeding on the plant. In so doing a bacterial or insect poison is apparently injected into the plant, which, passing to the growing crown, seriously interferes with the normal development of the leaves. The nature of the poison is not well understood, and for practical purposes it makes little difference. It is sufficient to know that if the insect is feeding on the beet it will blight, and that blight (referring to blight characterized by symptoms which will be discussed after a little) cannot be produced without the insect's attack.

Beets will blight no matter how old, but the younger the beet the greater will be the damage. Beets are very tender until they have grown eight to ten leaves, and study of the insect on the spot is really valuable, as there is no cure-all which can be applied. Weather conditions play a very important part; cold, wet winters killing many, while dry, warm ones will result in the survival of some to reinfest the fields. No spray can be used which will reach them, as they gain their food by sucking, and to be effective the spray must reach every one. This is an impossibility, due to their active movements, shyness, and quick flight on the approach of danger, and to the scarcity of the individuals which will produce damage. Parasites will prove of little value because of the variable number of insects from one year to another.

As the insects usually come onto the field in numbers, any remedy must be cheap, quick and applicable to a large area at once. As stated before, a knowledge of the insect's habits is necessary to determine this point. Where much damage is done it will pay the beet sugar interests, either mill or growers, to get together and hire some good entomologist to make this study. If the time of the insect's appearance is known, the time of planting can be planned accordingly. The whole idea is to bring the plants to the twelve-leaf stage by the time the insects appear, or else to delay planting, or, rather, the appearance of the seedlings until after the insects have arrived and are settled. When possible, the first way will usually prove to be the more satisfactory.

In connection with the planting, the judicious use of irrigation water is advisable when the insects first appear in the fields. This tends to drive them off and at the same time provides conditions for the plant's growth so that it will have greater resistance. In order to use irrigation water, the beets must have at least four leaves.

The main factors to bear in mind, then, in controlling the beet blight are:

(a) A knowledge of the insect's local habits; (b) a twelve-leaf growth when the insects arrive, and (c) a judicious irrigation to hold off the insects and to stimulate the plant.

Blapstinus (sp.).—These are black, rather dusty looking beetles, one-third of an inch long, which can be found traveling the beet fields in the spring when the seedlings are coming up. They do damage by nipping previous to this are very sensitive to insect attack. But after they have from twelve to fourteen leaves the damage will be materially reduced. This is due to the fact that only the new leaves which are produced are blighted. The older ones remain normal. Therefore when a plant has grown twelve leaves it is still capable of making considerable growth even without the aid of the new leaves formed, and while the plant continues to blight in its new growth, it has impetus enough to produce a marketable, although smaller, beet. When small beets are attacked they make very little additional growth. While they seldom die, they remain dwarfed and stunted and never amount to much. The reason that blighting is so pronounced after thinning time is because the insects which are present are scattered over the field by the thinning gang and become generally distributed. Moreover, one-twentieth as many plants must now withstand their onslaught because of the large number of beets removed in thinning. Each insect will blight every beet it feeds upon, so that with migratory insects only a few are needed to do a great deal of damage.

The chief characteristics of blighted beets is the thickened, prominent veins with small bunches or swellings in them. Accompanying these are a thickening of the leaf tissue, a darkening in color, and a generally distorted, incurling habit of growth of the foliage, so that it forms a close-clustered, cabbage-like head. A big mass of fibrous roots occur along the seams of the main root, which carry large quantities of soil and give a bewhiskered appearance to the beet. The texture of the root is hard and woody, making it difficult to cut in the mill. Rings of a blackish or brownish hue are present which rapidly blacken on exposure to the air. The juice is intensely bitter to the taste.

To successfully work out a method of control, a study of the habits of the insects is necessary in each locality. If the insect is natural to the section, the spread from its food plants—Atriplex, Russian thistle, sage brush, etc.—will depend much upon climatic conditions. If the descent upon the beets is from other valleys or sections of the country the conditions determining the flight of the insect will be purely local. For this reason, only a

GOOD SPECIMENS OF BEETS.
BLIGHTED AND NEMATODE BEETS.
Blighted, two pots on left. Nematode, pot on right.
BLIGHTED BEETS.

the tender seedlings and sucking the juice, so that in many cases the stand will be seriously curtailed.

The beetles usually winter as adults in old fence corners or around buildings. They lay their eggs in the field and the young develop in the soil.

Because of their habits they are rather hard to deal with. Pasturing the fields with poultry or turkeys previous to and at the time the beets are coming up will give comparative immunity. At the same time many other injurious insects will be destroyed. Cleaning up corners and all stray trash will go far toward ridding the fields, as the insects must then travel beyond their confines to get winter quarters. The use of 50 per cent more seed in sowing, and earlier sowing, to precede the arrival of the insects, is advisable.

Once the beets have two true leaves they are beyond danger.

Cutworms.—Cutworms are the young of certain moths. They are ugly, mottled brown, rather smooth caterpillars which feed at night and hide in crevises during the day. They are one and a half inches long when mature.

They damage the beets by cutting off the young plants and by feeding on the leaves of older ones.

The use of arsenate of lead on the older plants will effectually stop their work. To protect the young plants a poisoned bait of clover sprayed with arsenate of lead should be spread in the fields previous to and at the time of sowing the beets. In this connection the edges of the field should receive special attention. Turkeys and poultry are also useful in reducing the damage from this source.

Wireworms are hard, yellow, shining worms, from different sizes up to one inch long, living in the soil. They are the young of ordinary click beetles. They attack the roots of the beet and are mostly serious when the beet is very young, for by eating the young, tender roots they kill out the beets.

Wireworms are always worse in sod, clover or grass land, or after corn, potatoes or beans. When land is once infested the pest must be partially starved out by either summer fallowing the land and keeping down the weeds, by growing crops which they will not attack, or by sowing corn poisoned with strychnine and harrowing it in. Another method is to poison potatoes or wads of succulent vegetation with strychnine and place them around the fields under boards early in the spring.

A further desirable prevention is the removal of all trash, so that the adult beetles will have no place to hibernate during the winter.

Wireworms pass two years in the ground. Their presence can be detected by pulling out wilted beets and examining the beet and the soil around where the beet was growing.

Chewing Insects.—There are a large number of insects which are fond of the foliage of the beet—caterpillars of various kinds, canker worms, woolly bears and a host of others. These can be controlled by spraying the foliage with arsenate of lead. For the web-worms it is necessary to spray before the insects are protected by their webs, as the spray cannot penetrate these.

By spraying early and repeating the spraying often enough to keep the additional growth covered, the beets can be successfully protected.

Bordeaux mixture will prove a desirable repellant for flea beetles. When spraying for plant diseases the flea beetle will be taken care of at the same time.

Sucking Insects. Plant lice and thrips are examples of these. They require a dose of kerosene emulsion whenever they become numerous. Care must be taken to hit the insects with the spray, and to reach the parts of the plant where the insects are most numerous.

Conclusion. When an insect becomes numerous enough to cause uneasiness it is well to consult the mill agriculturist or send specimens to the nearest state experiment station for identification and information as to the proper control.

Beyond the mere hint at the subject, entomology is beyond the scope of this text.

Fungus Troubles.—Foremost among the fungus troubles is "leaf spot" *(Cercospora beticola).* This is the result of the growth of a fungus inside the leaf tissue. The fungus is a parasatic plant like mistletoe on oak, dodder on alfalfa, Spanish moss and the like, which grows from a small seedlike body. These "seeds" are blown about in the air and fall on the leaf. They germinate as soon as a little moisture is present, sending down little threadlike, bulb-tipped suckers into the leaf through which the fungus gains its food. When numerous the drain on the beet will result in impaired vitality and a lowered yield.

The disease is easy to recognize by its characteristic formation of shrunken spots at the points of infection. At first these are about the size of the head of a pin but they gradually increase until they are about one-fourth inch in diameter. If numerous several will coalesce, and pale brown or ashy gray patches of leaf are the result. The edge of the more or less circular spot is a purplish color and it is at this point that the fungus is getting in its active work, the dead and shriveled tissue having been drained dry. It is rare that the leaf spot is fatal for new leaves are formed to take the place of those devitalized by the fungus. But there is no question as to the reduction of sugar and weight from the ravages of the disease.

Sprays have not been remarkably successful but the use of Bordeaux mixture is recommended. If put on when the plants are very young and repeated at intervals of two or three weeks it will prove partially successful.

The breeding of plants naturally more resistant to the disease seems to be the most promising way of controlling it. This, however, is a matter beyond the scope of the farmer. It is a question receiving attention from the more progressive seed growers and something is likely to be done along this line.

Discontinuing the growing of beets on land which is badly infested for two or three years is a prescription which has been recommended, with a view to reducing the fungus.

Another leaf-spot *(Phyllosticta betae)* has been reported from certain sections and the above remarks will also apply to it. Its appearance is about the same as the *Cercospora.*

Beet Scab is another fungus trouble, this one affecting the roots instead of the top. It is caused by the same organism *(Oospora scabies)* as that which produces scabby potatoes. The roots show roughened, woody, brown patches of warty-like excresences which are the result of the formation of an abundance of corky tissues induced by the activities of the fungus. Beets and potatoes should never follow one another where this disease exists. An over abundance of water will produce conditions favorable for scab development and proper regulation of the water supply is essential.

Beet Rust (Uromyces betae), characterized by small brown pustules or pimples on the leaves which give off a copious brown powder, is seldom serious, but it will surely attract attention is present in any amount. Cold, damp weather is favorable to the development of this disease. Spraying with Bordeaux mixture will check it should it become serious enough to warrant a control.

A *Downy Mildew (Peronospora Schachtii)* has been reported from one section. It is characterized by downy, cobweb like growth on the undersides of the leaves. Bordeaux is the remedy.

A *Soft Rot* of the roots caused by bacteria *(Bacterium teutlem)* will sometimes occur on wet land. The avoidance of such land or the supplying of proper drainage will be the remedy.

The *Rhizoctonia Root Rot (Rhizoctonia betae)* is another outcome of too cold or too wet soil. It attacks both seedlings and adult beets. The following paragraph will describe it more in detail:

Seedling Root Rot.—When beet seedlings on being drawn out of the ground show blackened root tips or brownish, juicy spots on the roots it is evidence of root rot. It is caused by a fungus or fungi which are present in all soils. It gains a foothold on the seedling when the vitality of the plantlet is weakened. Root rot only attacks plants growing in cold, wet, uncongenial soils.

If the disease progresses far the stand will be cut down and in some instances seriously impaired. A change of weather to warm, dry spells will often save a crop suffering from this trouble.

Precaution consists in holding off planting until the land is warm enough to start and carry on germination rapidly and evenly. When the soil is cold to the touch it should not be planted. Plants once attacked by root rot are beyond remedy. When the attack is quite general so that most of the plants are suffering from it, replanting will be necessary. But when there is enough healthy plants to give a stand nothing need be done other than to insist that in thinning the largest and most vigorous plants be left.

Seedling root rot is sometimes confused with a natural condition of the root which comes when the beet has two or three true leaves. The outer epidermis then splits lengthwise and gradually shrivels away until it becomes nothing but a black, thread-like string. This is an entirely normal condition and is no cause for alarm.

Crown Rot.—This is caused by bacteria or fungi of different kinds gaining admittance into the growing heart of the beet, through cavities formed by rapid growth of the beet. A rich soil, an overabundance of water, too much organic matter in the soil, too much stimulating fertilizer, hot forcing weather or a combination of two or more of these conditions which result in an overstimulance of plant growth which will cause the beet to grow a soft, watering crown and to have a tendency to split just below this crown. Bacteria and fungi gain admittance and, with the moisture which collects from fogs, rain, dew or irrigation, produce crown rot.

The furnishing of proper conditions for steady beet growth will largely do away with this trouble. If it starts, air-slaked lime or wood ashes dusted over the plant will go far towards correcting the trouble.

Physiological Troubles.—In addition to the insect and fungus troubles the beet will sometimes show symptoms which cannot be traced to either of these. Such troubles when they entail the derangement of the natural functions of the plant, are called "physiological" troubles.

Sprangley roots due to hardpan is a physiological trouble. Naturally the correction of this will be the elimination of the hardpan.

Compound Tops is another case of this kind. It is the result of excessive growth of the beet (as described under "crown rot"). Instead of one top being sent up, the original splits, and several are produced. An open cavity usually accompanies it. The correction lies in the providing of right soil conditions, neither too rich nor too moist, so that excessive growth will not result. Compound top beets are always large beets but their sugar content is poor, and they are not satisfactory for manufacturing purposes.

Compounds tops will always form as secondary growth when the beet is preparing to send up seed stalks. These seed stalks are the natural outcome of a desire on the part of the beet to reproduce itself when growth is completed or when the plant receives a sudden check.

Seed Stalks will form with little attendant secondary growth early in the plant's growth if any serious check spells followed by dry, or the reverse, are apt to cause the plant to produce seed stalks. It is a tendency on the part of the beet to perpetuate its kind in case poor growing weather is to come. Seed formation is usually accompanied by a loss in sugar (although there are some sections which are an exception to this) and such beets are as a rule unfit for milling purposes.

Lack of Plant Foods.—The lack of certain of the main elements required by plants for their normal development produces certain physiological disturbances. When the leaves turn yellow before maturity and are reduced in size from no apparent cause (such as hard soil) it indicates a lack of nitrogen.

When the leaves do not turn lighter when mature, but wither while still remaining upright and the usual dark shade of green they indicate a deficiency of phosphoric acid.

A tendency to curl and wither quickly in sunlight, with the presence of large yellow spots, later turning brown, and the rather sudden change to this condition from the rich, dark green indicates a lack of potash.

These symptoms presuppose proper methods of growing the crop.

Animal Troubles.—Under this heading must be recorded the presence of the worst sugar beet pest in our American fields—Nematodes or eel worms *(Heterodera Schachtii)*. To the casual observer the eel worms are more like insects than animals.

Only the females are visible to the naked eye. They appear as small, whitish sac-like or bead-like protuberances about one-sixty-fourth of an inch in diameter on the fine feeding roots of the beet. The males are only visible under a microscope. There they appear like small thread-like eels.

The young are produced from eggs and when hatched they crawl around until they find a suitable place to settle down and feed. The females soon lose their power of locomotion and develop into something little more than a living sack full of eggs. They appear on the roots like little spots of mold, but when squeezed between the thumbnail and finger squash into a liquid-like mass.

The males do not lose their power of locomotion for a considerable period but work around at ease.

The Nematodes are very destructive. The extent of the damage can be judged from the following: Fifty beets were taken from both a Nematodes infested patch and from healthy beets near by. The two lots were taken from the same field, from beets raised under the same conditions, and were but a dozen or twenty feet apart. They were about four months old. The weight of the infested beets was two pounds nine ounces for the lot; the healthy beets weighed sixty-eight pounds six ounces.

If a small, irregular spot of undersized beets appears in your field among the healthy beets a number should be carefully dug up, the clinging soil gently washed off and the fine roots examined for the females. Samples of the beets should also be forwarded to the nearest Experiment Station for further examination.

The Nematodes will feed on almost anything if forced to it. To combat them in the field, irrigation water must be kept off the patches and no more beets raised there. Alfalfa is a good crop to put in as the Nematodes seem to fail on it. Absolutely clean cultivation for two years will also tend to starve them out. For very small patches fumigation with carbon bi-sulphide or formalin will prove feasible. Whether trap crops, fumigation, rotation or fallowing shall be practiced depends on the size of the patch, the degree of watchfulness which can be exercised, and the amount of work which can be done.

There is no worse pest than the Nematodes and their presence in our beet fields, even if in only two instances, is good grounds for alarm. Nematodes beets will not be knowingly accepted by the mill as the danger of spreading them in the wash water is very great.

Gophers, Moles, Ground Squirrels and Rabbits all feed upon the beet.

For *Rabbits* wire fencing to keep them off the fields will prove effective, or a couple of good rabbit dogs will produce comparative immunity. When the rabbits are numerous the old fashioned rabbit hunt cannot be beaten.

For *Moles* trapping is best, while irrigation will destroy large numbers.

For *Gophers* conscientious trapping will rid fields if there are not too many alfalfa or neglected fields near by for them to breed in. With both moles and gophers early spring trapping is best as one caught then counts for a dozen later on.

Gophers will also take poisoned baits if put onto their runways.

For trapping gophers the California Maccabee trap is hard to beat. The trap is placed in the entrance of the burrow, staked with a wire and the entrance then closed with a handful of green grass or weeds.

Irrigation will also destroy large numbers of them. When putting the water on, the levees and high places should be watched as the gophers, forced out by the water, seek these spots to remain until the water subsides. A good fox terrier at such a time will prove a most desirable aid.

Ground Squirrels may be destroyed when the ground is wet by the use of a wad of cotton, burlap or old cloth half the size of one's fist, saturated with carbon bisulphide, tossed into the open burrow, followed by a lighted match (to ignite it), and the entrance then closed with a shovelful of earth. In doing this work it is a good plan to close all entrances a day or two before the work is to be done, and then confine attention to those which are reopened. The saving in the amount of carbon used will more than offset the extra labor. Care should be exercised not to have lighted pipes or other fire around the carbon as it is very inflammable. The can containing it should always be kept closed as the substance is very volatile.

For poisoning, grains, sweet potato, water melon rind, beet root, raisins and prunes are all good. Strychnine is the best poison to use. Grains can be used to best advantage when the vegetation is green, while the succulent things will give best returns during the dry seasons.

The best all around grain *formula I have found is:

Whole barley or wheat	20 pounds
Starch paste	1 pint
Strychnine sulphate	1 ounce
Sugar	⅛ ounce

The grain should be placed in a receptacle large enough to hold it easily. One pint of water is then brought to a boil and two tablespoonsful of laundry starch, previously dissolved in a little cold water, is slowly added to the boiling water, to form when well cooked a paste about the consistency of cream. The strychnine (previously powdered if in crystals) and the sugar should then be added to the hot starch paste and the mixture well stirred until thoroughly incorporated together. While still hot it is poured over the grain and the whole thoroughly mixed until each kernel is coated. It is then set aside to cool.

In scattering the poison, only a few kernels should be used near each burrow. If too large a supply is left the squirrel will become suspicious and refuse to touch it. The grain should be scattered on the hard dry ground along the runways and not in the loose soil at the mouth of the burrows. A point to bear in mind is to look for the presence of young growing grain at the mouth of the burrow. If this is present it is a sign that the place is unoccupied and the putting of poison here would be a useless waste.

To add poison to the other substances mentioned insert a crystal of the strychnine (or as much as can be held on the point of a knife) into pieces of the material of a size large enough to handle easily. With raisins or prunes a bit of poison is put into each one.

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*This is the formula worked up by the Biological Survey of the U. S. Dept. of Agriculture.

CHAPTER IV.

Improvement of Our Agriculture.

When discussing the value and need of rotation crops, the subject of improving our agriculture was discussed at some length. European soils have been farmed for hundreds of years longer than ours yet European countries in many instances, are producing more to the acre than are we. France harvests over 23 bushels of wheat to the acre with her so-called "worn out" soil. We produced in the same year a trifle over 11 bushels.

Germany in 1907 produced one-fifth as much wheat from one-eleventh the acreage as did we. In other words, her yields, like France's, was over twice ours.

Holland and Belgium harvest over twice as much rye as do our greatest rye producing states. Germany produced nearly 140 per cent more than do we.

And so it goes. Germany in 1907 harvested 70 per cent more barley than our best producing states, 135 per cent more oats, and 112 per cent more potatoes to the acre.

Figured on an acreage basis (as compiled by Truman G. Palmer) Germany's figures are very instructive:

	United States. Bushels.	Germany. Bushels.
Wheat	14.0	29.6
Oats	23.7	58.2
Rye	23.8	38.2
Barley	16.4	25.7
Potatoes	95.4	205.3

Germany teaches us a lesson. And as our population increases we shall be forced to do as Germany has done—learn the principles of intensive farming. And into this scheme the sugar beet is bound to play an important part, just as it has done in Germany. It is far better to sell sunshine and rain off the farm in the form of sugar than nitrogen, phosphoric acid and potash. While a certain amount of the latter are needed in the form of grain crops to feed the people, the former will go far towards fitting the soil for the better production of the latter.

These facts are being more appreciated as time goes on, and the sugar beet in consequence is receiving more of the attention to which it is rightly entitled. What the sugar beet has done for Germany it will do for us. This shows in the following table (inserted here again for the purpose of illustrating this point):

Average Crops Per Acre Showing Increase After Beets.

	In Pounds.	In Per Cent.
Wheat	444	24
Rye	216	15
Barley	422	25
Oats	563	42
Peas	849	86
Potatoes	6,874	102

This shows the increase in yield of staple crops after beets were introduced into the rotation over the yields on land not planted to beets. They indicate why Germany's agriculture is ahead of America's.

Tariff.—And this brings us to the matter of a tariff to protect an industry which needs and deserves protection. The good to be gained from the culture of the sugar beet in connection with our general agriculture is a matter of nation-wide knowledge on the part of our keen witted, clear sighted, thinking men.

The tariff is a business question pure and simple. And like all other business propositions the procedure will go forth which will result in the most good for the greatest number of people. The tariff is not a moral question any more than is any other business proposition.

It is not the author's purpose to create a political discussion, but simply to point out that the advancement of our beet sugar industries with their many attendant beneficial influences on the agriculture of the country must be protected. To know what a business needs requires a knowledge of that business. The beet sugar interests know they could not exist a day without protection. If put in competition with cheap tropical sugars they would go to the wall. Prosperity depends not on trade but on production.

Tariff acts should be compromises of all the interests.

The national policy should be, and is, to stimulate production. When producers are prosperous every one is prosperous, as there is money to pay for goods.

It is a wise policy, therefore, which protects the sugar industries, or any other legitimate producing interest of the country, while at the same time measures are instituted for protection against internal abuse of that protective policy.

Under "Statistics" the rapid rise of the beet sugar industry is shown. The amount of money which an industry of this scope brings in—$20,000,000 for beets alone—indicates the wisdom of protecting it.

CHAPTER V.

STATISTICS.

Amount of Sugar Produced—Average in Long Tons for Five-Year Periods.

	Beet Sugar.	Cane Sugar.
1855-1859	....	136,939
1860-1864	....	116,931
1865-1869	400	20,947
1870-1874	480	60,979
1875-1879	100	82,501
1880-1884	647	114,816
1885-1889	894	128,630
1890-1894	8,597	203,821
1894-1899	31,943	284,207
1900-1904	144,892	266,835
1905-1909	344,314	336,857
1909-1910 (1 year)...............	457,562	335,000
1910-1911 (1 year)............	455,511	311,000

(From U. S. Dept. of Agri. Yearbook.)

The averages of the last ten years in beet sugar production are of interest as they show the rapid rise of the industry.

Year.	No. Mills Running.	Beet Acreage.	Average Yield Per Acre. Tons.	Sugar Manufac'd. Million Pounds.	Average Sugar.	Average Purity.
1901	36	175,000	9.6	369	14.8*	82*
1902	41	216,000	8.7	436	14.6	83
1903	49	242,500	8.5	481	15.1	83
1904	48	197,500	10.4	484	15.3	83
1905	52	307,000	8.6	625	15.3	83
1906	63	376,000	11.2	967	14.9	82
1907	63	370,500	10.1	927	15.8	83
1908	62	364,500	9.3	851	15.7	83
1909	65	420,000	9.7	1,024	16.1	84
1910-11....	61	398,029	10.7	1,020	16.3	84

(From the United States Dept. of Agriculture Yearbook.)
*Means in beet.

(The End.)