GARDENING

STOUT

NEW-WORLD SCIENCE SERIES

GARDENING

An Elementary School Text

EATING OF THE SCIENCE AND ART OF VEGETABLE GROWING

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GARDENING

AN ELEMENTARY SCHOOL TEXT
TREATING OF THE SCIENCE AND ART
OF VEGETABLE GROWING

By A. B. Stout, Ph.D.
Director of the Laboratories
New York Botanical Garden

ILLUSTRATED
WITH PHOTOGRAPHS AND DIAGRAMS
AND WITH PEN DRAWINGS BY
MARY E. EATON AND OTHERS

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THE HOUSE OF APPLIED KNOWLEDGE

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Publishers and editor offer *Gardening* to the schools with every confidence in its sincerity and practicability. They believe it to be that rare product in the publishing world, a text in a subject that holds a secondary place in the schools, worked out with the same skill and attention to details that are given to the making of texts in subjects having a major place in the curriculum. World Book Company shares the author's conviction that gardening should be taught in our schools. Its hearty accordance with a pedagogy that combines knowing and doing in an almost perfect way might easily have been forecast from the motto, "The application of the world's knowledge to the world's needs." Alike to the friends of school gardening and to those who do not yet realize the educational richness of the garden field, this volume is commended

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PREFACE

The author is one of those who firmly believe that the teaching of gardening in every school would yield very rich returns educationally. The author believes, further, that the best instruction in the subject must include *both* classroom work and practice in the actual growing of plants. An intellectual basis for the work that will lift it to a plane above a mere manual apprenticeship and an opportunity for the practical application of knowledge gained are alike necessary.

It is with the earnest wish to serve both teacher and pupil and with the hope of further extending good teaching of gardening that this text has been prepared. The aim has been to make it as easy as possible for the teacher to present theory and practice together, and by making the practical directions very full and concrete to make it possible for the teacher to devote his time more to the wider aspects of the work. It is hoped that such a text will not only save the time of teachers but will also serve as a guide to those of less experience in their work.

The first part of the book deals chiefly with the most important facts and principles of growth and reproduction in garden plants. The deliberate aim is to give the pupil an appreciation of the plant as a living thing and an understanding of how it lives. The later chapters deal chiefly with the various garden crops and the practical work of growing them.

The writer has been a home gardener all his life, and in his experimental work in plant breeding he has had occasion to grow many thousands of plants. Furthermore, he has been a teacher in elementary school, high school, normal school, and university; and for nearly three years at the New York Botanical Garden he taught gardening to classes of convalescent soldiers and sailors, many of whom were receiving their first instruction in the subject. Naturally, the present volume has been colored by personal experience. Some of the chapters consist in large part of material presented to the classes of soldiers and sailors. Yet in adapting the work to younger beginners, countless changes in matter and method of presentation have been made in the author's own material, and the views of other teachers of gardening and the subject matter presented by them have been carefully considered. It is hoped that the book will prove useful to teachers and pupils, and that the needs of different sections of the country have been adequately met.

ACKNOWLEDGMENTS

For help most generously given during the preparation of this volume the author is under obligation to many persons. In the list of those who have read most of the galley proofs and from whom many helpful criticisms and additional statements of fact were received are W. E. Larson, Principal of the County Training School of Algoma, Wisconsin, previously for several years Inspector of Rural Schools for the State of Wisconsin; J. L. Randall, now in charge of gardening in the Fitchburg, Massachusetts, Normal School, formerly Director United States School Garden Army; W. R. Beattie, Extension Horticulturist, United States Department of Agriculture; Hugh Findlay, of the Department of Agriculture and Horticulture, Columbia University, New York City; and Kenneth Boynton, formerly Supervisor of the Garden School for Convalescent Soldiers and Sailors, now acting Head Gardener in the New York Botanical Garden. The chapter on "Insects in the Garden" was read by F. H. Chittenden, and the chapter on "Diseases of Garden Plants" by W. W. Gilbert, both of the United States Department of Agriculture and both of whom contributed suggestions and ideas of the greatest value. Many of the uncredited photographs which so splendidly illustrate the processes of gardening were secured from W. C. McCollom, Islip, New York.

To all the persons named above, to all those who have contributed illustrations as acknowledged, and to various other persons not mentioned who have answered letters of inquiry or whose writings have been consulted, the writer wishes to express deep appreciation.

It has indeed been a pleasure to write this little book.

A. B. Stout

New York Botanical Garden

GARDEN LORE

To plow, to plant, and to hoe may not be the chief end of man, but it was the first great work that was given him to do; and that he might keep it in mind for all time, he had a pledge that the seed-time should never fail.

OLD FARMER'S ALMANAC

There's something wonderfully soothing in having your fingers in Mother Earth. It seems to take the restlessness out of one. FRANCES DUNCAN

The man who has planted a garden feels that he has done something for the good of the world.

CHARLES DUDLEY WARNER

The ground must touch a man before he can amount to much. ABRAHAM LINCOLN

To own a bit of ground; to scratch it with a hoe; to plant seeds, and watch their renewal of life, — this is the commonest delight of the race, the most satisfactory thing a man can do. CHARLES DUDLEY WARNER

A good garden saves the butcher's bill, and keeps down the doctor's bill, too. OLD FARMER'S ALMANAC

Boy or girl, you need to feel plowed ground under your feet; you need the contact with growing things in the ground; you need to handle a hoe, [*and*] *gather the garden vegetables. . . . You need to take part in the digging and weeding and planting. . . . You need to smell* [*the soil*], *to feel it, to work in it.* DALLAS LORE SHARP

To smell a turf of fresh earth is wholesome for the body.

THOMAS FULLER

Watching things grow, things that his own hands have planted, is one of the chief joys of the householder.

James G. Needham

Behold this compost! behold it well! . . . It gives such divine materials to men, and accepts such leavings from them at the last. Walt Whitman

A soil, to be fertile, must above all things be light and pliable, and this condition we seek to bring about by the operation of plowing. Virgil

If you keep square with the work, you feel greater pride and satisfaction in it, and everything goes smoother.

Old Farmer's Almanac

Head work in the garden is worth quite as much as hand work. Old Farmer's Almanac

In planning garden operations for the year remember that rotation, clean tillage, and selected varieties will do much to help you in your fight against both insects and plant diseases. Such measures wisely taken bring other advantages. Old Farmer's Almanac

Farmer Wideawake will have the plans for his crops all made before spring opens, so as to be ready to plow and plant each crop as soon as the proper season arrives.

Old Farmer's Almanac

Acquaint yourself with an intelligent system of crop rotation — Use your brains — Then when you are certain and your program is ready, DIG IN HARD.

Old Farmer's Almanac

Not only does succession planting utilize limited areas most intensively; it is sound economics from every point of view. Old Farmer's Almanac

Fall plowing now demands our attention. With minor exceptions all the land which is to be put under cultivation next year should be plowed before freezing. It is not necessary nor desirable to turn the furrows smooth and flat as in spring plowing. If the land is left quite rough, the action of the frost during the winter will be more effective in breaking up the soil and reducing it to a fine powder.

OLD FARMER'S ALMANAC

It should not be forgotten that all the heavier soils are improved by fall plowing, which should be pushed whenever opportunity offers. OLD FARMER'S ALMANAC

'Tis the farmer's care that makes the field bear.

OLD PROVERB

Perfect tilth, no less than suitable enrichment, is essential for bumper crops. OLD FARMER'S ALMANAC

Nature will always find some mischief to do in idle land. Give her the opportunity and you shall repent in another season when you find redoubled labor essential to keep the garden clear of noxious growths. OLD FARMER'S ALMANAC

In the garden more grows than the gardener sows.

OLD PROVERB

The rich garden soil from which you have taken an early crop will bear weeds if you do not put it to use for production of something better. OLD FARMER'S ALMANAC

A weed, as it grows from an inch to a foot high, increases a thousand-fold in bulk or weight, and exhausts the soil in proportion. OLD FARMER'S ALMANAC

Cultivate! A hard crust over the surface of the ground is almost as fatal to the growth of annual plants as would be a coat of paint to the growth of a pig.

OLD FARMER'S ALMANAC

If a good crop is to be obtained, it must be well fed and well cared for, and the work must be done at the right time.

OLD FARMER'S ALMANAC

Land for roots needs to be worked deep and fine.

OLD FARMER'S ALMANAC

Cauliflower for fall and winter use may be set after your earliest peas. OLD FARMER'S ALMANAC

Cucumbers and melons can be grown in the spent hotbed in summer, and the little plot made to do double duty.

OLD FARMER'S ALMANAC

The gardener no sooner gets the mastery of the destructive insects, than there comes another plague called fungi, which, if not hindered or destroyed, will greatly injure the crops of the garden. OLD FARMER'S ALMANAC

Now that bugs and blights abound, be up and at them; but be sure to identify your enemy before you begin your fight. OLD FARMER'S ALMANAC

The warfare of the insect tribes upon the vegetable kingdom is a continuous performance at which the gardener cannot afford to be an idle spectator.

OLD FARMER'S ALMANAC

He who would have a good garden must visit it daily, that he may discover and destroy the insect enemies before they do any essential injury. OLD FARMER'S ALMANAC

The race between man and the creeping things of the earth is said to be very equal. As soon as man is master of one, a new one appears, more persistent in its destructive work and more difficult to conquer than any that has preceded it; consequently man has to seek new and more effective poisonous compounds that will kill these enemies, and not injure the vegetation upon which they feed.

OLD FARMER'S ALMANAC

The gardener must watch diligently lest he get outgeneraled by the bugs, worms, and creeping things of the earth, which are ready to devour nearly every plant that grows.

OLD FARMER'S ALMANAC

Snug up and get things in order for a long winter.

OLD FARMER'S ALMANAC

Now that the harvest is past, it is time to prepare for winter. Secure the vegetables in the cellar before freezing weather comes. OLD FARMER'S ALMANAC

Observe these hints and you will find it easy to keep winter vegetables in good condition: Keep onions cold, dry, and well ventilated. Hang cabbages by the stump in a cool cellar not too dry. Bury turnips, carrots, parsnips, and beets in moist, fine soil in a dry, cool cellar.

OLD FARMER'S ALMANAC

We have drawn from the land all that our industry compelled it to yield, and our crops in store and the book of receipts will tell us the story of the year's work.

OLD FARMER'S ALMANAC

CONTENTS

FIG. 1. "To hear or read, and then to do, —
That is the perfect school."

GARDENING

CHAPTER ONE

OBJECTIVES AND METHODS[1]

> A school garden worth the name is not a teacher's garden, or a philanthropist's garden, but a garden worked out in thought and act by happy, purposeful children.
>
> DORA WILLIAMS

PROBABLY the first systematic elementary instruction in gardening in the United States was given at Roxbury, Massachusetts, in the year 1891 in the school conducted by Mr. H. L. Clapp. Eleven years later (1902) Mrs. Henry Parsons started the first children's "school farm" in New York City in connection with the Park Department. Since then, gardening in one form or another has become a part of the education and training of children in many cities. Recently, under the stimulus of the war-time necessity for increased food production, various national, state, city, and other agencies throughout the United States joined in efforts to provide instruction in gardening, especially in connection with the schools. According to records collected by the United States Bureau of Education from 2258 towns and cities, at the close of 1919 there were 2,500,000 pupils enrolled in the garden work.

In some states the instruction is more or less organized for the entire state, and in at least one state, New Hampshire, there has been adopted a definite plan for teaching gardening to all children in the elementary schools of

[1] This opening chapter is intended for teachers and school officials and is not for study by pupils.

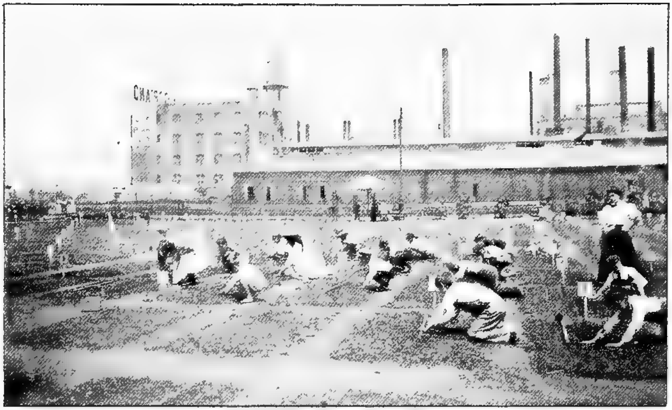


FIG. 2. School gardens were started in New York City in 1902, in connection with the Park Department. This photograph was made in 1906, on the site of the first "school farm."

the entire state. The teaching of gardening has become widely recognized as an important part of the educational work of the public schools; the aims in teaching it and the best methods to be employed are now rather clearly defined.

There seems to be general agreement that the primary purpose of *school* instruction in gardening is *educational.* But the instruction in the school aims also to encourage the making of home vegetable gardens whose chief function is that of *food production.* Obviously, it is through the combination of school and home activities that the educational values of gardening and its uses to the home are to be realized.

Experience in the teaching of gardening seems to indicate clearly that the most successful teaching of the subject is *that which combines classroom and textbook instruction with actual practice in the work of gardening.* In general, the relation between the classroom and the outdoor work is quite clear. Classroom and textbook instruction deals primarily with principles; it presents the laws of plant growth and the fundamental relations between plants and their environment in such a way that their essential needs are understood. In all lines of human effort, those individuals who understand the reasons for what they are doing excel in practical work; thus, to obtain the best gardens we must give the pupils an understanding of plant life. Secondarily, the classroom and textbook instruction deals with the special needs of the various vegetables and the special methods of planting and caring for them in such detail that with but little additional direction in the garden itself the beginner can grow these successfully.

In the actual outdoor work the pupil learns the *art* of gardening. Mechanical skill in the use of tools is acquired through their use. Acquaintance with plants is gained from contact with them. The best methods of caring for crops are learned by experience. Yet (for the beginner especially) there is constantly the application of principles learned in the classroom and judgment of the methods employed according to the results attained. The art of gardening becomes an intelligent application of principles to methods, with eventually the discovery of the most suitable methods.

When both the principles and the practice of gardening are taught, the subject has great educational and utilitarian values, and it has taken its place in school curricula because experience has shown that the pupils absorb these values. It is closely related to the pupil's present life, so that he understands the significance of what he learns and does; and it correlates as few studies do with the various subjects of school interest. Much of the ordinary work in nature study can be taught in gardening in a manner which gives additional interest and purpose to the work. The daily experiences afford excellent subject matter for language exercises, and there is opportunity for the application of problems in arithmetic and for practice in honest business methods. The history of garden vegetables involves knowledge regarding geography, climate, and the climatic needs of the various vegetables. Gardening also teaches much regarding the principles of breeding and improving plants and may afford practice in such breeding.

In the larger schools, training in canning and drying garden produce and in the construction and use of the special storage rooms and cellars can be given with the coöperation of teachers in domestic science and in manual training. In most cases, however, teachers and parents must lead in these activities.

Naturally, the simpler aspects of gardening are best learned in the lower grades. As pupils advance in age, more is learned. The vista of knowledge is ever widening. There are constantly new discoveries to be made. There are constantly the exercise of judgment and the practical application of knowledge suited to stimulate and tax the child's growing mental powers.

Thus the pupil can follow the subject progressively through the grades without undertaking work too diffi-


States Relations Service

FIG. 3. An individual plot garden with paths between the plots.

cult for him in the earlier years and without repetition in the higher grades of the simpler facts with which he is already familiar. In agricultural sections especially, the teaching of gardening naturally and progressively leads to the more advanced teaching of agriculture. This flexibility and exhaustlessness of the subject is another reason why the teaching of gardening has been so successful in the schools.

The organization of the practice work in gardening has received much attention. Several types of gardens have been successfully developed in meeting the various conditions existing in different communities.

The school garden or school farm of individual plots is one in which each pupil of the school or of certain grade

Van Evrie Kilpatrick

FIG. 4. An individual plot garden without paths. The rows of vegetables run uninterruptedly across the field and the corners of the plots are marked only by stakes.

or grades has a garden plot, usually of small area. The pupil cares for his own plot, but the work of planting, caring for, and harvesting the crops is all done under the direction of a teacher and supervisor.

Formerly, in school-garden work very generally, individual plots were assigned to the pupils, and especially in Los Angeles and New York City this plan is still followed with marked success. This method stimulates individual effort, and it provides individual plots for children who have no opportunity for home gardens. But in most places it has been replaced by the community grade garden and the school-directed home garden.

The community school or grade garden is one in which all the children of the grade or the school jointly participate in the work of preparing the soil, planting, and caring for the entire garden plot. The purpose of the garden is chiefly educational, and a large part of the instruction and training is accomplished by the time school closes in June. Some four or five pupils of the grade who have shown special interest and diligence are selected to care for the garden through the summer, but always under proper supervision. These pupils share in the crops that mature within this period. The time required of a child for the care of a grade garden during vacation is usually not more than two half days a week.

The community garden serves excellently for group instruction at the school. It provides practical training for the children who can have no home garden; moreover, the united efforts of the community insure a continuous care of the plot, which is not always possible when the individual-plot method is followed. A fur-

States Relations Service

Fig. 5. A school-supervised home garden. These gardens are especially successful in suburban communities and in smaller cities and towns; yet in the crowded city of New York space was found for more than 80,000 of them in 1917.


North Dakota Agric. Expt. Sta.

FIG. 6. The best place of all for a garden is on the farm. Here land is abundant, so the rows should be planted wide for horse-cultivation. The photograph shows a model farm garden of one third of an acre in North Dakota.

ther advantage of the community garden is that it gives the pupil training in coöperative effort—practice in that "team work" which is so essential in a democracy.

The school-supervised home garden is made at the home of the child under the supervision of a teacher; and for successful participation in the care of the home garden a pupil is given a certain amount of school credit. The garden is visited at intervals during the growing season by a supervisor who gives advice and instruction and judges the activity and interest of the pupil. Certain records are kept by the pupil, and these are correlated with the work done in the school.

School supervision of home gardens is undoubtedly one of the best means of combining school and home activities. It aims to promote and improve the home

North Dakota Agric. Expt. Sta.

FIG. 7. The same garden shown in Figure 6, later in the season.

garden whenever there is opportunity for one at the home of a pupil in the fourth grade or above. That many home gardens are possible even in large cities is shown by the fact that a school garden survey of New York City in 1917 disclosed a total of 83,898 children having their own home gardens.

But home gardens are especially successful in smaller cities and towns and in suburban districts of large cities, because here the conditions are often ideal for gardens of this kind. The size of the plot is frequently ample for the family needs, a well-drained site with rich soil can often be selected, and manure for enriching the soil is usually obtainable.

In the more sparsely settled rural districts especially, the opportunity for educational, vocational, and moral training through gardening is far from being utilized at present. Here, however, special supervisors and teachers must consume so much time in travel that the instruction becomes costly. Perhaps in the country the work in gardening should become a part of the more general boys' and girls' club work, with the same teacher for both the gardening and the other work. Certainly, under the stimulus of competent supervision and guidance and with proper credit in the school course, home gardening in the country can be made to yield at least as rich results as it now yields in towns and cities.

The demonstration or observation garden is chiefly for educational purposes. It supplements the school, grade, and home gardens, and serves to instruct the entire community, young and old alike. At the present time the most common observation garden is one that demonstrates a model home garden.

But an observation garden may serve other purposes. Plants not usually seen in the region may be grown, and new crops or new varieties of standard crops may be tested to determine if they are suited to local culture. A school can maintain hotbeds and cold frames, thus demonstrating their construction and uses and at the same time supplying seedlings of such crops as cabbage and tomato for transplanting to the home gardens.

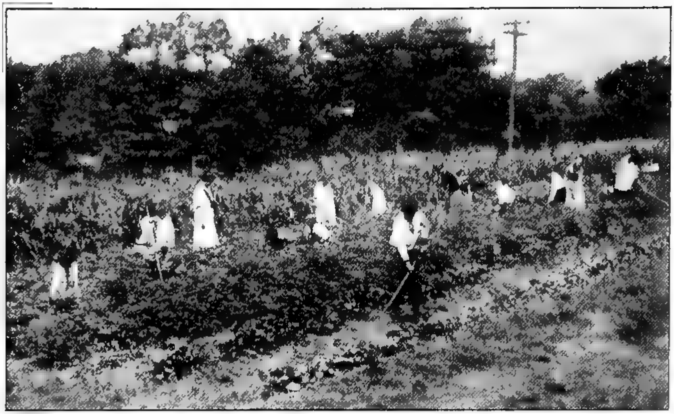
The observation garden can be used also for seed production, for demonstrations in plant breeding, and for practical instruction in agriculture and in the growing of plants of value in floriculture, horticulture, and forestry. As instruction in gardening becomes more general, demonstration gardens will undoubtedly be-

Van Evrie Kilpatrick

FIG. 8. A school demonstration garden. The pupil is shown the various operations of planting and cultivating his crops in this garden. Then he is able to use this knowledge in caring for his garden at home.

come an important factor in the work. They cannot, however, take the place of the school and home gardens, which must necessarily be the basis of the instruction and training.

The principal crops grown in school gardens are quite the same throughout the entire United States. The detailed plans for both classroom and practice work, therefore, will vary chiefly according to climate. In the more northern states, where the growing season is shorter and the outdoor work begins late, the garden work must be followed through the summer to be most effective. In the more southern states the long growing season allows many crops to reach full maturity before the



Raymond W. Swett

FIG. 9. The garden of the fifth and sixth grades in the Emerson School, Newton, Massachusetts. The children of one or more grades work together in the care of a common garden.

summer vacation begins; also many autumn crops can be planted after school again opens.

One of the best plans for organizing the grade gardens of a city in the northern states that has come to the attention of the writer is that employed at Newton, Massachusetts. Here grade gardens are maintained for the fourth, fifth, and seventh grades. In the garden for a fourth grade, radishes, lettuce, beets, Swiss chard, carrots, beans, and late squash are raised. These are all readily grown from seed sown in the garden. Radishes and lettuce yield crops before the close of school in June. Beans, beets, and Swiss chard give returns during the summer to the pupils who care for the garden through vacation time. Work in the same garden is continued by the class in the following autumn, when the squash crop is maturing and the beets, carrots, and Swiss chard are still producing. In the following spring squash is not planted, but corn, tomatoes, and kohl-rabi are added to the other vegetables grown. In the seventh grade potatoes also are planted.

The classroom work at Newton begins about March 1. The supervisor visits each grade about once in three weeks to give special instruction to the pupils and to outline the work of the grade teacher. In addition, all children of the fourth grade and above are encouraged to have home gardens.

Many other cities and towns have carefully worked out and put into operation progressive courses in gardening, but space does not allow even a brief discussion of them here.

The success which is attained in the teaching of gardening in any school depends on the efficiency of the organization and the coördination of classroom instruction with the actual practice in gardening. For complete success, especially in the northern states, a supervision that follows the garden through the entire summer vacation is absolutely essential. The quality of the instruction and supervision is dependent on the training, interest, and enthusiasm of the supervisors and teachers in charge. When it is well taught, the subject is one that naturally appeals to the child's needs for mental and physical training and to his normal desire to obtain immediate returns for expended effort.

CHAPTER TWO

REASONS FOR LEARNING GARDENING

I'd ruther kindo git the swing
O' what was *needed,* first, I jing!
Afore I *swet* at anything!

JAMES WHITCOMB RILEY

THE idea expressed by the poet in the above lines is a good one. It is always well to find out why we are doing anything before we spend time and effort on it. Here are some of the reasons for learning gardening.

Gardening is educative. The chief reason for learning gardening is that it gives us a store of useful and interesting knowledge we would be likely to get in no other way. Through his work the gardener learns about insects, soils, and weather. He works with living plants and comes to understand how they live and grow. Thus he learns to know nature and nature's laws, and how the workings of these laws affect his own life.

FIG. 10. Gardening is educative. Through his work the gardener learns many facts about plants, insects, soils, and weather.

FIG. 11. Gardening allows children to share in the family work. By carrying his share of the burden a child gains in self-respect and has a position of more dignity in the family circle.

Gardening allows children to share in the family work. It is wrong to accept something for nothing when we can pay. Through garden work children can give to their parents something for what they have received and are receiving from them. Excepting spading, garden work is light, and the average child of ten can do most of it. By taking up this work a child gains the respect of the older members of the family, and his ideas and wishes are more carefully considered in the family circle than they would be if he were not helping to carry the family load.

Another great advantage of gardening for many children is that it allows them to work with their parents or other older persons. Many parents play with their children but do not find time to discuss serious matters with them. Working with an older person in a garden

FIG. 12. Another great advantage in gardening is that it allows children to work with older persons. This gives an opportunity for talking over many important problems not connected with garden work.

gives a child an opportunity to talk over many important problems, and to learn much about the work in hand and also about the larger affairs of life.

Gardening gives an appreciation of property rights. We own our gardens. We know the thought and labor we have put into them and that without our labor they never would have existed. We know that what we have thus created by our own efforts belongs to us, and through an understanding of our own property rights we are led to understand the property rights of others.

Gardening leads to industry and an understanding of the importance of labor. By working in the garden we establish habits of industry, and through the garden we come to appreciate the value of labor and the importance of industry. When we care for a garden properly, it thrives and repays us in good harvests. When we spend only a little effort on it, the harvest is correspondingly scant. Thus we come to realize that men can have only that which they produce by their labor; that by labor we can create something for ourselves without taking it from any one else.

FIG. 13. Gardening gives an appreciation of property rights. Even a young gardener knows that the fruits of his labor rightfully belong to him.

Gardening gives practical business experience. Gardening often affords business experience through the sale of garden produce in the market or to neighbors. Such experience enables a young person to learn how to deal with others and gives him a training and a knowledge of business methods that are of the highest value in almost any profession or walk of life.

Gardening gives healthful exercise. Gardening gives healthful outdoor exercise, which is especially beneficial to school children and to those who in later life work indoors. This exercise is varied, bringing into use many different muscles, which rests the nervous system instead of tiring it as fine and close work does.

For those inclined to be nervous, gardening is an especially valuable form of exercise. Because it is a light outdoor occupation, the work itself is soothing

U. S. D. A.

FIG. 14. Gardening helps to fix habits of industry. It is for the good of all that idle hands and idle land should be employed in this way.

F. L. Miller

FIG. 15. Through gardening we come to an understanding of the importance of labor. No gardener produces a crop like this without understanding that careful, persevering effort lies back of everything worth while. This splendid garden is a "Cook County School-Home Project" at Harvey, Illinois.

to tired nerves, and the feeling of ownership and the interest in watching the plants grow gives us satisfaction and peace of mind. Such a mental condition gives contentment of mind and stability of character, and helps to make good neighbors and good citizens.

FIG. 16. Gardening gives practical business training. This young gardener is preparing her tomatoes for market so carefully that there will be no complaints from her customers.

Gardening improves the family diet. Fresh vegetables are necessary to the health. They supply bulk in the diet; they furnish calcium, iron, and other minerals that are often lacking in other foods; and from them we get substances called *vitamins* that are absolutely necessary for health. Scurvy is due to the lack of a vitamin found in abundance in tomatoes, turnips, cabbage, and other fresh vegetables. The vitamins that make milk and butter so necessary in the diet are collected by the cow from the grass, and the same vitamins are found in all green vegetables. Recent experiments with animals make it seem probable that the chief reason for tooth decay is a lack of vitamins in the diets of

U. S. Bureau of Education

FIG. 17. Gardening gives healthful exercise. Such exercise is especially beneficial to school children, who must spend much of the day indoors. This garden is in Los Angeles.

children. If these are furnished in insufficient amounts, the teeth are soft and the enamel covering is defective.

It will always be cheaper for many families to raise their own vegetables. Often idle land and idle hands can be used to grow them. There is no expense for hauling and shipping, and buying and selling, when vegetables come direct from the garden to the table. In this way all loss in shipping is avoided also, and often the vegetables are in much better condition for use. Experience shows that *those families that have their own gardens use vegetables freely. Many other families suffer in health for lack of fresh vegetables.* It is especially important that those who are not able to buy vegetables in abundance should raise them for themselves.

Knowledge of gardening an aid in earning a living. The gardener is able to raise for himself and his family vegetables that it would cost money to buy in the market. Also, through the sale of surplus vegetables, a garden often increases the money income of the family, thus making it possible to provide more comforts for the family or to save more of the income for future use.

Furthermore, more people make a living by growing plants than in any other way, and to millions of persons a knowledge of gardening is a direct aid in making a

FIGS. 18 and 19. Gardening improves the family diet. In fresh vegetables there are vitamins and minerals that are often lacking in other foods.

Van Evrie Kilpatrick

FIG. 20. A knowledge of gardening is often an aid in earning a living. More families make a living by growing plants than in any other way, and hundreds of thousands of other families help out their incomes by cultivating home gardens. These boys and girls are receiving a training that is more likely to prove useful than any other practical work that could be given them.

living. Market gardeners, fruit growers, and farmers are all engaged in raising plants and selling their products, and these industries will always be important. What a person learns as a child in gardening will be very useful indeed if his life work is in any way connected with the growing of plants.

Thus we see that we are likely to be well repaid for any time we spend in learning gardening. And this is the more true because much of the garden work can be done in time that would not otherwise be spent in a profitable way.

Questions

Name some reasons for learning gardening. Why is the exercise obtained in gardening especially valuable? What substances necessary for a healthful diet are furnished abundantly by fresh vegetables? Why is it often better to raise fresh vegetables than to buy them?

Name persons in your neighborhood who either make a living by growing plants and selling the produce or increase the family income in this way. Is the number of persons who make a living by growing plants large as compared with the number in other important occupations?

Things to Do and Observe

1. *To determine whether gardening is profitable.* Determine whether or not a garden pays by keeping an exact account of everything done or money spent, and of everything harvested from your garden throughout the entire garden season. Keep this record in some permanent form (perhaps the diary form will be easiest). At the end of the season put down in one column just what the garden cost in actual expenditures for labor, tools, seed, fertilizers, and other materials, and include also an estimate of the value of your own labor. In another column set down the market value of all produce obtained, whether used by the family, sold or given away, or allowed to go to waste. Compare the two totals.

After balancing the money account decide whether the education and training you have received through caring for the garden is of any particular value to you.

2. *To find out whether families without gardens use vegetables freely.* A wealthy farmer in a farmers' meeting argued that it was cheaper for him to buy strawberries for his family than to raise them, but when questioned about it, he admitted he had bought none the past year. Find out, if you can do so, whether families who buy their vegetables use them as freely as those who have gardens.

CHAPTER THREE

HOW PLANTS LIVE

> One who raises plants gets pleasure out of his craft in proportion as he knows what they are doing in root and branch or in flower and fruit, at every turn of the season.
>
> James G. Needham

A plant has its needs, such as food, water, air, sunlight, and protection from its enemies; and if these needs are not supplied, it will grow poorly or may even die. If a garden plant stands in poor soil, or is much shaded, it grows only slowly. If it remains wilted continuously for several days and nights because of lack of water, it is almost sure to die. And when plants are not protected against insects and disease, many of them are injured or destroyed. Like the gardener himself, the cabbages, beets, carrots, and other plants which he grows are *alive*, and to be healthy and vigorous, they must have the things that they need for living and growing.

The work of the gardener. The task of the gardener is to supply the needs of his plants — to give them the best possible conditions for growth. The gardener, therefore, enriches the soil so that it will supply an abundance of food materials. He cultivates among his plants so that the water will be retained in the soil. He thins the seedlings in the rows and destroys the weeds, so that each plant will be able to secure sufficient food materials, water, light, and space to develop fully. If necessary, he also sprays his plants to protect them from insects and disease. And he does all this work in order to give his plants better conditions for life and growth.

FIG. 21. A gardener is a caretaker of plants — one who watches over them and sees that their needs are supplied, so that they will flourish and yield him an abundant crop.

FIG. 22. "Weeds and bugs claim much of the attention of the gardener; but if he be master of his business, he will destroy the former as soon as they germinate, and the latter during the earliest stages of their growth." *Old Farmer's Almanac*

A gardener is, therefore, a caretaker of plants — one who watches over them and sees that their needs are supplied, so that they will flourish and yield him an abundant crop.

Learning to be a gardener. One may learn much about how to grow plants by growing them. By observing how our garden plants develop under different conditions, we may judge what is best for them. It was thus that our ancestors learned to raise plants, for gardening is indeed an old art. In fact, many of our important food crops were cultivated before the days of written history. Man learned *how to grow plants* long before he knew much about *how plants grow.*

But within the last hundred years plants have been carefully studied in order to find (1) how they obtain food materials from the soil, (2) what sorts of food materials they need, (3) what they take out of the air, what they give off into the air, and how they do this, (4) what advantage they have in being green, (5) how they may be protected from their enemies, and (6) how they may be grown to yield especially early crops or crops of unusually fine quality.

This knowledge of how plants live and grow has now become a science, and an understanding of this science is of the greatest help to the gardener in his work. For knowing how plants live makes it more interesting to work with them, and the scientific gardener can care for his crops far more intelligently and supply their needs far better than one who does not understand the reasons for what he does. In the following paragraphs, therefore, we shall explain how a plant lives.

The parts of a plant. Let us examine some garden plant, such as a bean or a corn plant. We notice that it is composed of a stem and leaves which grow upward into the air, and of roots that are in the soil.

Now let us look at a young radish about ready for table use. At first glance its leaves appear to grow directly from the roots. But careful examination shows that there is really a short stem between the leaves and the main root; and when the plant shoots up into flower, we see that it has the same parts as the bean and corn and other plants that we grow in our gardens. Much as garden plants differ in form and appearance, they are all alike in having (1) *leaves* that are exposed to the air and sunshine, (2) *roots* that burrow in the earth and darkness, and (3) a *stem* connecting the roots with the leaves.

FIG. 23. Young seedlings of beet and bean plants, showing how extensive is the root system even in very young plants. The roots of the plant in the center are 8 inches long, almost three times the length of the parts above ground.

The root system. Suppose we try to get out of the ground all the roots belonging to a plant. We may loosen the earth with a trowel or a spading fork and with our hands break away the soil and sort out the roots. Because the roots are so delicate and so interwoven in the soil, many of the smaller ones are broken in spite of the greatest care. But we readily find that there are great numbers of roots, that they are very finely divided, and that they go deeply and spread widely in the earth.

As a matter of fact, the root system of a plant often has a greater spread than the parts which reach out into the air. A small plant of the garden radish with leaves scarcely 2 inches long may have roots that go down to a depth of 6 inches. The roots of the corn plant have been traced to a depth of 6 feet 9 inches, and to a spread of 7 feet 3 inches sidewise from the plant, and the roots of an old alfalfa plant have been found at a depth of 12 feet 6 inches in the soil. Studies have been made which show that the roots of a wheat plant, if placed end to end, would extend to a distance of 500 to 600 yards; and it is said that the roots of a large pumpkin plant thus placed would extend to a distance of 15 miles.

The work of the roots. Of what use is this great network of roots to the plant? *The roots anchor the plant in place, and they take in from the soil the water and the minerals that the plant must have for its life and growth.* One of the chief reasons why plants must not be crowded in planting is that they require much room underground for their roots to develop, so that they can obtain the supplies of water and minerals that the plant needs.

The work of the leaves. Every important organ or part of a plant or animal has a use. What do the leaves do for the plant?

(1) *The principal work of the leaves is to make food for the plant.* In the cells of the leaves there is a green coloring matter called *chlorophyll*, and through the action of this, sugar is built up when the sunlight falls on the leaves. This process will be discussed more fully in a later chapter (page 47).

(2) *The leaves help the plant also in securing a sufficient*

supply of the minerals that it needs. These minerals are dissolved in only small amounts in the soil water, and to get enough of them a plant must take in large quantities of water. The greater part of this is given off by the leaves into the air in the form of water vapor. This evaporation of water from the leaves is called *transpiration.*

The advantage of transpiration to the plant is that it allows large amounts of water containing weak solutions of minerals to be taken in by the roots, and when the water is evaporated the minerals are left in the plant. The minerals in water remain in a kettle when the water is boiled away; similarly, the minerals remain in the leaves when the water is given off into the air.

But in dry weather, transpiration is at times a disadvantage to a plant. Sometimes the roots do not absorb water as fast as it evaporates from the leaves, and so the plant wilts. One of the chief tasks of the gardener is to provide enough water for the needs of his plants; for in hot, dry weather plants are often injured because the water is lost too rapidly from the leaves.

The stem and its work. *The stem supports the leaves so that they will be distributed widely in the air and can receive much sunlight.* It also carries the sap between the roots and the leaves. The water and minerals that are taken in by the roots as raw materials pass upward through the stems to the leaves, where they are manufactured into food for the plant. This food is then carried downward through the stem to the roots or to any growing and working part of the plant. By holding up great numbers of leaves to the light, the stem

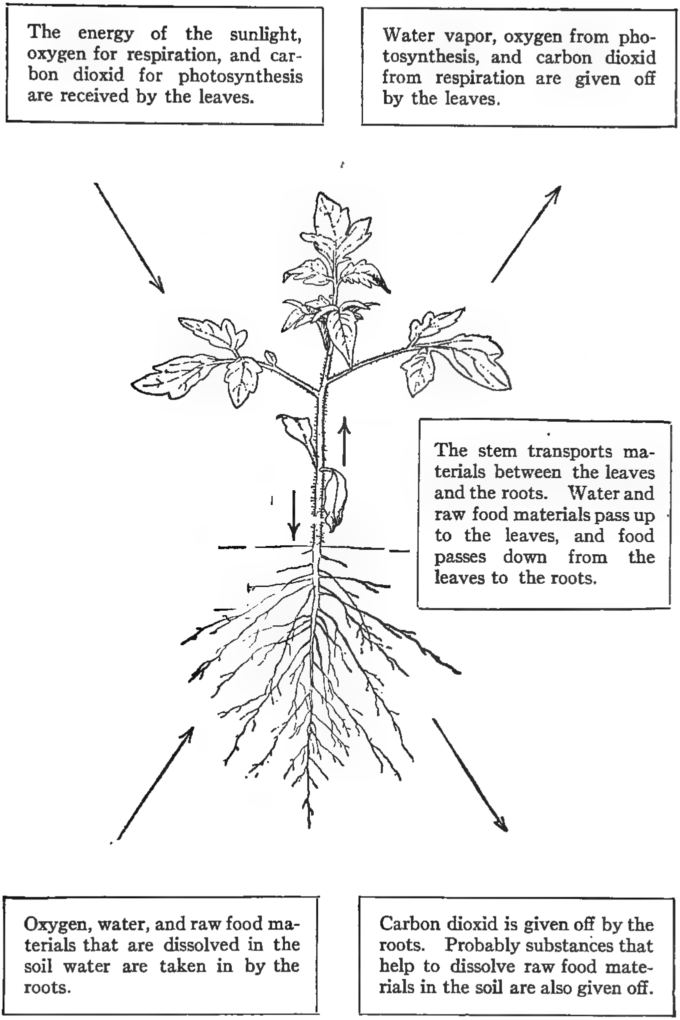


FIG. 24. Diagram illustrating the work of the different parts of a plant.

makes it possible for a plant to manufacture much food, and the stem has in it "vessels" or bundles of long, slender tubes that allow water and food materials to be distributed throughout the plant.

The plant as a whole. Thus we see that the *roots*, *stem*, and *leaves* all work together to promote the life of the *plant as a whole.* The roots anchor the plant and supply water and minerals; the leaves manufacture sugar; and the stem makes it possible for the plant to display many leaves to the light and for water and food to be carried where they are needed in the plant. Thus roots, leaves, and stem each have a work to do, and the work of each is necessary for the life of the plant as a whole.

Respiration in plants. All the living parts of a plant breathe or respire. Like animals, plants take in oxygen and use it in breaking down their foods. In this way they obtain the heat and energy that they use in maintaining their lives and in growing; and like an animal, a plant gives out carbon dioxid as a waste product when it respires.

Respiration is one of the most important life processes, for it releases the energy that keeps a plant or an animal alive. It may be compared to the burning of wood in a stove or of coal in the fire box of an engine. Fuel is consumed or combined with oxygen, and a gas (carbon dioxid) is given off to the air. Heat and energy to do work result from the chemical change. A plant does not consume as much food as an animal that is actively moving about and doing work with its muscles. But a man cannot live without taking in oxygen and burning food in his body, even though he lie entirely motionless; and in like manner a plant must respire to keep up its life.

Supplying the needs of plants. From our studies thus far we see that four of the great needs of a plant are *air*, *light*, *water*, and *mineral salts*. Most garden work is done in order that these four needs of the plant may be met so that it will live and make the best growth. In later chapters we shall learn in some detail how gardeners make conditions favorable for the growth of their plants.

Questions

Name some of the principal needs of plants. State a few of the gardener's tasks in caring properly for his plants. How did our ancestors learn to grow plants? What advantages does our modern knowledge give us in caring for plants?

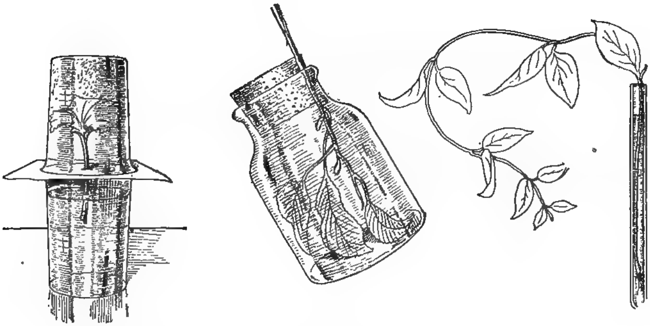
Name the parts of a typical garden plant. Tell how far the root systems of certain plants extend. Does a plant have any prominent parts, such as roots or leaves, that are not useful to the plant? What is the function (work) of the roots? Of the leaves? Of the stem?

What is respiration? What do plants obtain through respiration? What waste product is given off when a plant or animal respires? To meet what needs of plants is most garden work done?

Things to Do and Observe

1. *To note the extent of the root system of a young plant.* Select a young plant about four inches tall. A beet, tomato, cabbage, or bean growing in the garden or in a pot or flat will do. Try to get all of the roots out of the soil. Note the great number of rootlets and how fine the smallest of them are. Compare the spread of the roots with the spread of the parts above the ground. What does this show about the work of roots? About the room that plants need?

2. *To show that a leaf gives off water.* Draw the stem of a healthy young leaf (cabbage or geranium will do) through a hole in a square of cardboard. Seal about the stem of the leaf with



Figs. 25, 26, and 27. Experiments to show that leaves give off water.

paraffin heated only to the melting point (too hot paraffin will kill the stem of the leaf and spoil the experiment). Then arrange the experiment as in Figure 25, making sure that the upper drinking glass fits snugly to the cardboard.

Arrange two other glasses in the same manner but make no hole in the cardboard and omit the leaf. Set both pairs of glasses in the sunlight for several hours.

Where does the water come from that collects in the glass inclosing the leaf? What happens to a leaf if it is not supplied with water?

The second pair of glasses is used as a "check" or "control" in the experiment. Why is it advisable to have a check in experimental work?

That a plant gives off water can be shown also in the manner indicated in Figures 26 and 27. When the experiment is carried out as suggested in Figure 26, the twig is left attached to the tree. When done as indicated in Figure 27, the leaves should be placed in the sun.

Transpiration may be demonstrated also by turning a large glass vessel over a potted plant, after the pot has been wrapped in sheet rubber or oilcloth fitted closely about the stem to prevent evaporation from the soil. The amount of water evaporated by a potted plant in a day can be determined by wrapping the pot as described above, weighing the pot and plant, and reweighing at the end of 24 hours.

3. *To show that plants respire.* Soak 50 seeds of the garden pea in water for 24 hours. Then place them in a drinking glass with strips of wet blotting paper intermingled. As soon as the roots protrude, the young plants are ready for use. Secure two wide-mouth bottles of one-half-pint size with corks to fit tightly, and two small vials or wide-mouth bottles that can be placed within the larger bottles. Buy some limewater or make it.[1] Place 25 germinating seeds in one bottle, together with wet pieces of blotting paper; then place an open vial or small bottle nearly filled with limewater among the seeds. Cork securely. Prepare the other bottle in the same way but omit the seeds; this is the "check" by which we can measure the action in the first bottle. Place the two bottles side by side in a warm room.

Observe frequently for a period of 48 hours. Note that the surface of the limewater in the vial containing the seeds becomes coated with a white layer, and that this does not appear in the other vial. This white material is lime carbonate, formed by the chemical union of lime dissolved in the water and carbon dioxid in the air of the larger bottle. Where does the carbon dioxid come from? Why is it that no carbonate forms on the limewater in the check bottle?

Now remove the cork from the bottle with the seeds and insert the burning end of a splinter of wood. Why does the flame immediately go out? Test the air in the other bottle in the same way. Why does the flame continue to burn? What do the growing pea plants remove from the air, and what do they give off into the air?

[1] Crush a large lump of unslaked lime. Pour enough of this pulverized lime into a bottle to fill it about one-third full. Then add twice as much water as lime. Cork the bottle and shake vigorously. Set aside for 24 hours; then pour off the clear water, being careful not to disturb the lime at the bottom. Filter this water through a fine cloth or filter paper, and keep it in a tightly corked bottle.

CHAPTER FOUR

HOW PLANTS GROW

> The wonder of growth! There is more mystery in the way one bean vine climbs its pole than in all the detective stories ever printed.
>
> NEVIN WOODSIDE

WITHIN a seed is a little plantlet. When the seed germinates, this tiny plant breaks out of its case, sends its root down into the earth, and pushes its stem and leaves up to the air. Day by day it becomes larger, its stem gets longer and thicker, new leaves appear, and finally flowers and fruits are produced.

Or a bud on the tuber of a plant like the Irish potato or Jerusalem artichoke, or on the root of a sweet potato may produce a new plant. At first the bud is very small, but it increases in size until a full-grown plant is formed.

What happens inside a plant when it grows? How

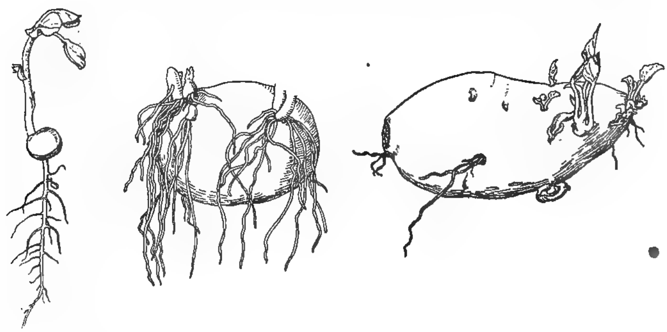


FIG. 28. "Tall oaks from little acorns grow." Other plants also have small beginnings, all our garden plants coming from either tiny plantlets in seeds or from buds on stems and roots. The illustration shows early stages in the growth of the pea, Irish potato, and sweet potato.

are the new parts formed? Where in a plant is growth most actively going on? To answer these ques-

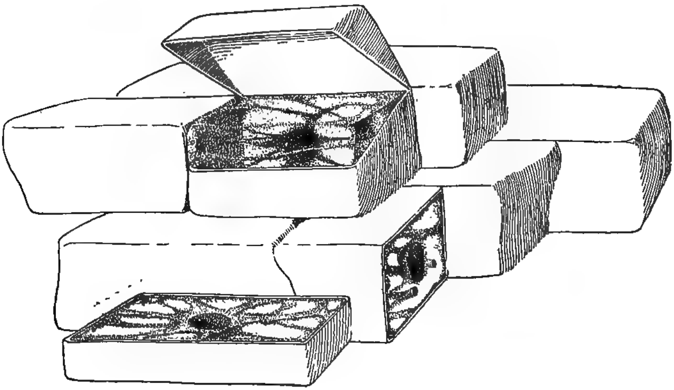


FIG. 29. Diagrammatic representation of a group of plant cells. Above is a cell with the wall cut and a part of it lifted to show the contents. Below are cells cut crosswise and lengthwise. All plants and animals are built up of these cell units; but, of course, many kinds of cells are very different from the box-like structures here shown.

tions it is necessary to explain the structure of a plant.

The cells of a plant. If a thin section or piece of a plant is examined under a microscope, it is seen to be made of tiny units that are called *cells*. Each cell, like a loaf of bread, has length, breadth, and thickness. The outer part of the cell is a wall, and if the cell is living, within the wall is a soft, living material that appears somewhat like white of egg. In a full-grown plant cell the most active part of its substance is found chiefly in a layer just within and completely lining the wall, in strands of this material that extend from the lining layer to a rounded body called the *nucleus*, and in the nucleus itself. Within the living cell there is much watery material known as the *cell sap*.

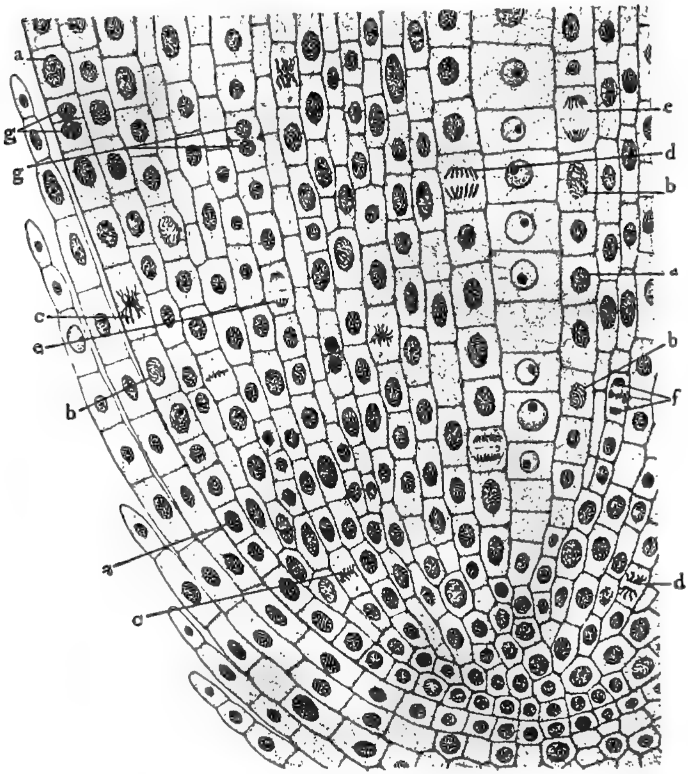


FIG. 30. Part of a section cut lengthwise through the tip of an onion root, as seen through a microscope. The entire root tip is composed of cells which are shown in different stages of division in the lettered series. It is through the multiplication of the cells and the increase in size of the older ones that growth takes place.

All the parts of a plant are composed of cells. The roots, stems, and leaves are each built up of a multitude of these little units. The food is made within the cells, and oxygen is used within the cells. It is the cells that need water, and *it is the cells that are alive and grow.*

How a plant grows. Plants grow in two ways: the cells *multiply*, and they *increase in size.*

When a cell divides, the nucleus first separates into two parts. Then a wall or partition grows across the cell. Thus two cells are formed where there was but one before. In the tips of growing stems and roots, where the growth is active, the cells are dividing very rapidly, and this multiplication of cells causes growth in these parts.

In older parts of the plant, growth is largely due to the increase in the size of the cells. This enlargement of the cells is caused chiefly by the taking in of water, which collects within the cell. After a warm rain in early summer, the young corn plants take in water and the cells expand so rapidly that sometimes the amount of growth in a single night is noticeable. In the older regions of the root or stem a cell often has a volume one thousand times as great as the volume of one of the young cells in the growing tips. As the cell enlarges, its wall stretches, and new materials are formed in it, so it increases in size with the rest of the cell.

How new parts are formed. If we could see the plant at the very beginning of its life, we would find that it consists of *just one cell* within the young seed. This cell divides and multiplies and soon develops into the embryo or tiny plantlet which we find within a seed. The root which pushes out when the seed germinates is formed by a group of cells multiplying and enlarging very rapidly. Other cells build the stem in the same way. A branch of the stem or root is formed by a number of cells multiplying and growing out to make the branch; leaves, flowers, and all other parts arise from groups of cells that divide rapidly and push out beyond the cells about them. In this way new parts are formed. They are built from parts that already exist by the multiplication and enlargement of groups of cells.

Regions of growth in a plant. Growth causes stems and roots to increase in thickness, and there is very rapid growth in the ends of branches which causes them to increase in length. Young leaves and other parts that are just being formed are also places where rapid growth is taking place.

Stages in the life of a plant. A garden plant like a radish, a carrot, or a bean does not continue to grow indefinitely. It goes through the stages of its development, completes its life, and then dies. From the point of view of the gardener the life of a garden plant like a carrot consists of (1) a seed stage, (2) a nursling stage, (3) a building stage or stage of rapid growth, and (4) a stage of storing food and maturing seed.

In the seed stage the little plant is almost completely inactive or dormant. We say it is in the "resting condition." It respires very slightly. It does not grow.

In the nursling stage the plant begins to grow. At first it lives entirely on the food stored in the seed. But in small seeds like that of the carrot the supply of food is scant and the little plant must soon depend on the food it manufactures for itself. In the nursling stage a seed-

FIG. 31. Three stages in the life of the carrot. On the left is the nursling stage, in the center the building stage, and on the right the stage when the seeds are matured. In the nursling stage the plant requires especial care.

ling is tender, its roots are few and near the surface of the soil, and it is easily killed by heat, cold, drought, or other unfavorable conditions. At this time, therefore, it needs favorable conditions, and the gardener must provide these as fully as possible. His methods of growing seedlings, and of transplanting for certain crops (which will be discussed later), aim to nurse the plantlets carefully during the critical seedling stage of their lives.

In the growing or building stage the plant manufactures its own food *from the raw food materials gathered from the soil and air.* It now builds up the food which it makes into living matter and thus grows rapidly. The gardener is concerned with providing for his plants at this time an abundant and continuous supply of water and of the minerals that they draw from the soil, so that the cells will have an abundance of food for growth and the plants will reach their full size.

In the fourth stage, growth becomes slower and *food is stored away for the future use of the plant itself or for its offspring.* In the radish it is stored in the root and used later in the same season for producing the rapid growth of the flowering stem and for the development of seeds. In the carrot, beet, and parsnip the food is stored in the roots until the following season, when the flowering stem and seeds are developed. In the potato, food for the young plantlets that arise from the buds is stored in the tuber, and in the sweet potato in the fleshy roots. In the onion stores of food are found in the leaves that form the bulb, and in lettuce and cabbage in the clusters of leaves that make up the heads. In some plants,

FIG. 32. When a garden flourishes like this one, we know that the gardener has supplied the needs of his plants *before* they began to suffer.

like the squash, the food is found in the fruit; in peas, beans, and corn most of the food is stored in the seeds.

Importance of continuous care of plants. The growth and storage of food by a plant in its later life is but the accumulated result of the conditions under which it lived in its earlier life. Much depends on giving the young seedlings a good start, when they are, so to speak, getting ready to grow up. In this stage they are establishing the root system that must be developed before the top can be enlarged, and if the young plants become stunted and dwarfed it is difficult to get them to start rapid growth again. Every care also should be taken to keep plants growing continuously during the stage of most rapid development, for unfavorable conditions oft force them to flower and fruit before they reach fu size.

The good gardener knows that injury once done to h crops can seldom be repaired by any amount of later car so he supplies the needs of his plants *before they suffe* He prepares the ground properly and plants his see carefully, so that the seeds may germinate and sta vigorous growth at once. He cultivates the youn seedlings before the soil becomes compact and wee appear, so that they may come to the period of rap growth quickly and in good condition. When rainfa is scant, he waters his garden before the soil becomes dr He thins his seedlings before they crowd each other, an he pulls weeds before they overshadow and damage h plants.

All this he does because by experience he has learne that the growth his plants make and the amount an quality of food that they yield depend on the care the receive from day to day.

Questions

Describe a plant cell. In what two ways do plants grow Explain how new parts are formed. In what parts of a pla is growth most rapid? What are the four stages in the life garden plants? How does the storage stage of the carrot diff from that of the tomato? Compare the fruiting stages of the two plants.

Why do plants need special care during the seedling stag Why should the gardener try to supply the needs of his plan before they begin to suffer? Name some of the things a garden does to make conditions favorable for his plants.

Things to Do and Observe

1. *To study the structure of a stem.* Examine with the aid of a hand lens a freshly cut cross-section of a tree at least 6 inches in diameter. Note the pith in the center. It is composed of thin-walled empty cells. In some woods like the oak, ash, or hickory the openings made by cutting across the larger wood cells may be seen. Between the outer edge of the wood and the inner bark is a zone of living cells. These are smaller than the older woody cells, their walls are thin, they are filled with living material, and it is by the growth and division of these cells that the tree increases in diameter.

Garden plants have fewer woody cells than a tree or shrub, but their general structure is the same. Examine the stem of a cabbage, noting the pith and the ring of wood.

2. *To examine living cells.* If a low-power microscope is available, the teacher or pupil may strip off the outer layer of cells from one of the inner leaves of a fresh onion bulb, or make thin cross-sections of fleshy leaves and stems of plants (for example, cabbage) and mount them for examination. The leaves of many mosses consist of a single layer of cells, and these may be seen by examining the entire leaf with a microscope or even a good hand lens. In this way one can observe the cell walls, see that the living cells contain much transparent material, and that in the green cells the coloring matter is in rounded masses or bodies. Possibly the rounded but almost colorless body called the *nucleus*, shown in Figures 29 and 30, may also be seen. A little iodine run under the cover glass will stain the cell contents and often make the nucleus visible.

3. *To observe the region of most active growth.* With India ink, mark off into half-inch spaces a foot of the end of a growing vine. Then in a day or two note how much each space elongates. In this way you can easily determine the region of most active growth in the stem.

CHAPTER FIVE

THE FOOD OF PLANTS

There's magic done in plants.
O'er simple elements of earth and air,
A sun-beam wand is passed —
And food is there!

NEVIN WOODSIDE

WE live and grow on the food we eat, but a corn plant lives and grows without eating. It sends its roots out into the soil, spreads its leaves to the light and air, and week by week increases in size. Finally the ear appears with the kernels swollen with a rich store of food. The plant has lived, reached its full size, and at the end of life has a surplus of food on hand.

In our garden and field crops we find sugar, starch, oils, and the other foods that we live on, and these are not in the soil or air. Where do plants get them? What do plants use for food? Only in comparatively recent years have scientists been able to answer these questions.

The food of plants. In your study of physiology you learn that man and the lower animals use for food proteins, fats, and starch and sugar. Plants use these same foods.[1] The difference between the nourishment of a green plant and the nourishment of an animal is that *the green plant makes its own foods from water, carbon dioxid, and minerals,* while an animal cannot do this but must have its food already prepared for it.

[1] Sometimes carbon dioxid, water, and the various minerals used by a plant are called "plant foods." Sometimes these are called the "raw materials used in the making of food," or simply "food materials," and the term "food" is used to mean the sugars, starches, fats, and proteins that are built up from these substances. In this text the word is used (as it is in animal physiology) to mean the complex, built-up substances actually used in the nourishment and growth of the living matter of the cells.

The green plants can, therefore, build their sugar, fats, and proteins from substances which they take from the soil and air. They can build vitamins also, which it is believed an animal cannot do. So the green plants build out of simple materials all the complex foods used by the living matter of both plant and animal cells.[1] Plants can live without animals, but every animal is dependent on plants for the food that keeps it alive.

FIG. 33. Without eating, the corn plant has lived, reached its full size, and at the end of its life has a surplus of food which it has stored in the ear.

The manufacture of sugar. The first complete step in the manufacture of food by the plant is the making of sugar. When light falls on the chlorophyll, carbon dioxid and water are combined within the cells to make sugar. This process is called *photosynthesis* (Greek, *photos*, meaning light, and *synthesis*, meaning a putting together). Photosynthesis

[1] Plants also build wood, cork, gums, waxes, and all the various other substances (excepting minerals) found in them.

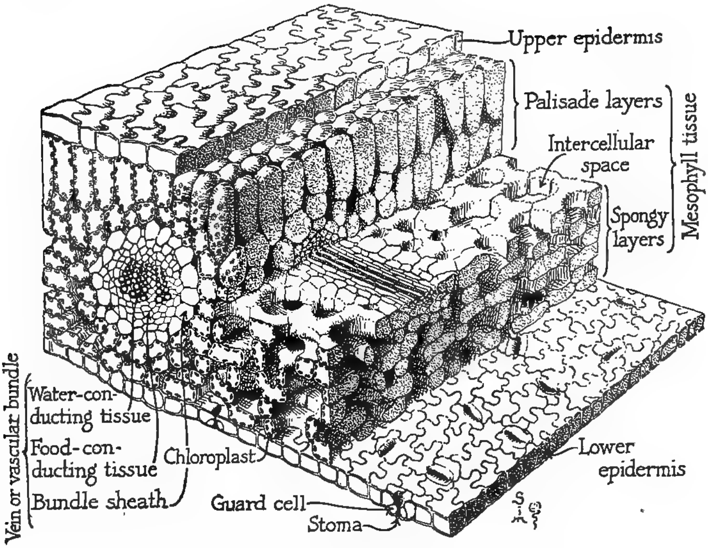


FIG. 34. Section of a leaf, very highly magnified.

goes on in all green parts of the plant, but takes place especially in the leaves.

Leaves as sugar-making organs. As the term *photosynthesis* indicates, the energy used in building up sugar is furnished by the light. Without light, plants cannot do this work; and when we examine a plant, we note at once that the broad, thin blades of the leaves and the way they are arranged on the plant enables them to catch large amounts of light. This makes it possible for the manufacture of sugar to be carried on rapidly by the plant.

But it is only when we examine the internal structure of a leaf that we understand how well fitted it is for carrying on its work. The sugar is made in the cells within the leaf. Most of these are loosely arranged; they touch each other on some sides so that there are air spaces between them. Thus part of each cell lies against other cells, and part is exposed to the air within the leaf.

On the outside of a leaf there is a very thin covering called the *epidermis*. This is composed of a layer of thin, flat cells closely joined together. The outside walls of these cells are thickened and usually covered with a wax-like material which does not allow water and air to pass readily through it. *This covering protects the softer and more tender cells within.* But on the lower side of the leaf of a garden plant (and in some plants on the upper side of leaves also) the epidermis has many tiny openings through which air and water vapor can pass.

Thus the inner portion of the leaf is in communication with the outside air through the openings in the epidermis. The oxygen that the cells need for respiration and the carbon dioxid needed for food-making enter the leaf through the little openings in the epidermis, and the excess of water brought up from the roots passes out into the air as vapor. The veins of the leaf are composed of vessels which connect with those in the stem. They bring the water and dissolved minerals from the roots to the leaf and carry away to other parts of the plant food that the leaves have made.

How starch is made. Starch is only a changed form of sugar, a form that does not dissolve in water and is suitable for storage within the plant. In nearly all garden plants the sugar is changed to starch before it becomes very abundant in the cells. Some of it is stored as starch within the leaf. But the sugar is also conducted to other parts of the plant to be used by them immediately for food or for storage. The tuber of the potato is an enlarged part of the stem where large amounts of starch are stored. The starch that has been stored in a plant can be again changed to sugar and transported to the parts where active growth is taking place or where seeds are being formed.

But while most plants change their sugar to starch for storage, a few plants do not do this — at least not until the sugar has become very abundant in them. From two plants, sugar cane and the sugar beet, the world's supply of sugar is obtained. Onions and sweet corn are rich in sugar, and wrinkled peas contain more sugar than smooth peas.

The manufacture of fats and proteins. From sugar, plants make oils, in which form many plants store a part of their food. From the olive, coconut, flaxseed, cotton seed, peanut, corn, and castor bean, oils are obtained which are used for many purposes by man.

The fats are present in larger or smaller amounts in all living plant cells. They are for the most part formed in the cells where they are found, and are not to any great extent transported from one part of the plant to another. They contain the same chemical elements as sugar and are believed to be formed from sugar.

Proteins are made by combining chemically nitrogen, sulfur, and sometimes phosphorus with the elements of the sugar. Minerals supplying these are obtained from the soil. Without an abundant supply of the minerals that are needed for building proteins, rapid growth in a plant is not possible.

The proteins can be made in any living part of the plant; but the materials of which they are built are most abundant in the leaves, and they are manufactured in larger amounts in the leaves than in other parts. From the leaves they may be carried to other parts of the plants for storage or for the immediate use of the cells in those parts.

FIG. 35. The gardeners are appropriating the food that the plants have made for themselves.

Materials necessary for life and manufacture of food in green plants. Ten chemical elements are necessary for the life and growth of a green plant.[1] Of these elements, oxygen, carbon, and hydrogen are used in largest amounts.

The oxygen used in respiration is secured chiefly from the air; that used for building purposes comes from water and carbon dioxid. The carbon is obtained in the carbon dioxid taken in from the air. The hydro-

[1] These ten elements are carbon, oxygen, hydrogen, nitrogen, sulfur, phosphorus, potassium, calcium, magnesium, and iron.

gen comes from the water which the roots absorb from the soil. The other seven elements are secured by the plant from various mineral compounds which it takes from the soil.

The minerals most often lacking in the soil are those that furnish nitrogen, potassium, sulfur, and phosphorus. These are often supplied in manures or other *fertilizers* (page 66). When the gardener enriches the soil, he is providing raw materials needed in some of the many building operations going on in the plant.

Garden plants are builders and storers of food. A weed, as a rule, uses its food for growth as fast as it makes it, and in its small seeds it leaves no considerable store of food that can be used by man. But a radish, cabbage, or bean plant makes food faster than it uses it and collects a surplus either for its own future use or for the use of its offspring. These stores of food we take for ourselves, and we have selected for cultivation in our gardens the plants that will lay up for us food in largest amounts.

The successful gardener gives his plants favorable conditions for food manufacture and provides them with abundant supplies of the raw materials that they must have for the work.

Questions

How does a green plant get its food? What classes of foods do plants build? What raw materials are used in making them? Why cannot animals live without plants?

What is photosynthesis? In what part of the plant does photosynthesis go on? When does it go on? Describe the structure of a leaf. What is the function of the epidermis? How do gases enter and leave the leaf? How do water and minerals get into the leaf?

How is the surplus sugar that is made by most plants stored? Can it be moved from one part of the plant to another? From what do plants make fats? Name some plants from which fats are obtained. From what are proteins manufactured? Where in the plant are fats and proteins manufactured?

What minerals needed by plants are most often lacking in the soil? How does the gardener supply these to his plants? Name one difference between garden plants and weeds.

Things to Do and Observe

1. *To examine the structure of leaves.* Peel off strips of both the upper and lower epidermis of leaves and examine them under the low power of the microscope. The colorless epidermal cells and the "stomata" surrounded by the green "guard cells" can be seen. Make thin cross-sections of leaves (most easily made from such fleshy leaves as the cabbage) and examine them. Permanently prepared sections may be bought from botanical supply houses.

2. *To show that starch is formed only in the green parts of a leaf.* Expose a plant having white-margined leaves (variegated geranium is excellent) to sunlight for several hours. Then remove a leaf and make a tracing of it, showing the green and the white areas. Place the leaf in a dish with enough alcohol to cover it. Heat gently on a stove or over an alcohol lamp or gas flame, taking care not to boil the alcohol so strongly that it will catch fire. The green coloring matter is thus removed and the entire leaf becomes almost colorless.

Obtain some iodine solution from a drug store. Add a little of this to thin starch paste and note the blue color of the starch. This is the iodine test for starch. Dip the decolorized leaf in water to which iodine has been added. The part of the leaf that contains starch will turn dark in color. Is starch found in the green or in the white area?

Test cut surfaces of a potato, turnip, radish, bean seed, or other vegetables for starch. Do not use too much of the iodine, or the blue of the starch may be somewhat hidden by the brown color of the excess iodine.

3. *To show that sunlight is necessary for the accumulation of starch in green leaves.* Expose a potted plant (for example, a

geranium) to sunlight during the day, remove a leaf (*a*), attach a label with string, and immediately place it in a bottle of alcohol. Place the plant in complete darkness for 24 hours. Then remove another leaf (*b*), attach a label, and place in the alcohol. Now, cut smoothly two disks from a cork stopper and carefully pin these on opposite sides of a leaf (*c*) so that they fit snugly and exclude the sunlight from the covered area. Expose the plant to direct sunlight for several hours. Remove leaf *c* and also another leaf (*d*) that has been left untouched. Test all four leaves with iodine for starch.

Is starch present in *a*? Was starch present in the leaves when the plant was placed in darkness? What became of the starch formerly in the leaves during the time the plant was in darkness? Was starch formed in *c* and *d*? Was it formed in the shaded area of *c*? What does each leaf show concerning the influence of light upon the accumulation of starch in green parts of a plant?

The above experiments can be worked with plants outdoors by selecting *b* very early in the morning and the other leaves after they have been exposed to sunshine.

CHAPTER SIX

THE SOIL OF THE GARDEN

Every clod feels a stir of might,
An instinct within it that reaches and towers,
And, groping blindly above it for light,
Climbs to a soul in grass and flowers.

JAMES RUSSELL LOWELL

THE roots of garden plants live in the soil. The fineness or coarseness of the soil, its looseness or compactness, its temperature, the food materials and the water present — all these influence the life and activity of the roots. Sometimes, an excess of substances like acids or alkalies is present; and the activities of animals and plants which live within the soil may benefit or harm the plant. The gardener can, in a large degree, control the conditions of the soil, and much of his success depends on his making them suitable to the needs of the plants that he grows.

In all his efforts to handle and improve the soil for the growing of his crops, the gardener needs to have in mind three points relating to the condition of the soil:

(1) The size and arrangement of soil particles, which we may refer to as the soil's *physical* condition.

(2) The richness in the various food materials which plants obtain from it.

(3) The amount and kind of water present in the soil and the soil's ability to hold water and supply it to the plant.

While these conditions are closely interrelated, they may be considered quite separately.

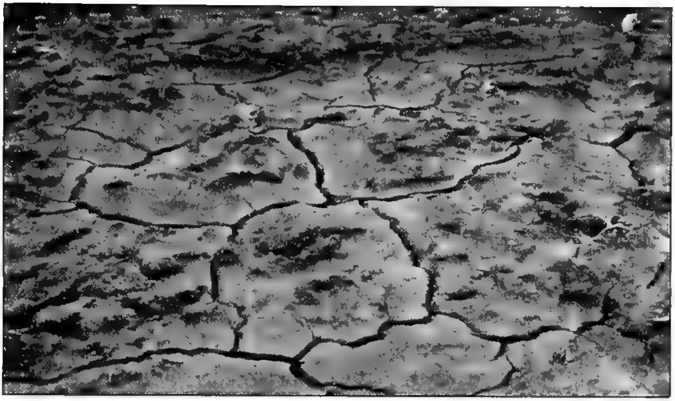
THE PHYSICAL CONDITION OF SOIL

How soils are formed. Soils are formed from the rock of the earth's crust mixed with the decayed remains of plants and animals. Through the action of air, water, and changes in temperature, the surface rock in the course of time crumbles into particles which form the rocky or mineral parts of the soil. Therefore soil may be said to be composed largely of rocks that have fallen into pieces. With a hammer one may pound rock into powder, thus reducing it to small particles like those which make up the soil.

The *organic* substances in the soil are formed by decay of plants and animals that die and fall to the ground. Organic matter that is well decayed so that it is black in color and in fine particles is called *humus*. The differences in soils are due both to the different kinds of rocks from which they were formed and to the amount of organic matter in them.

The breaking up of solid rock and of plant and animal remains into fine particles meets the first need of living plants, for it gives them a place to grow. It allows the roots to find their way in among the soil particles, thus making it possible for them to anchor the plant and to secure a supply of water and raw food materials.

Size of soil particles. The size of the rock particles in the soil may range from large bowlders to minute fragments of dust. The number of individual particles in a spoonful of ordinary garden soil is so great as to be almost inconceivable. It is estimated that in an ounce of coarse sand there are about one hundred billion



International Harvester Co.

FIG. 36. Soil that was not cultivated at the proper time and consequently became "baked" by the hot sun. The good gardener never allows his soil to get into this condition.

particles. In an ounce of the finest clay there are more than five times as many.

The size of the particles of organic matter in soil varies with the stage of decay. Leaf mold (formed from decaying leaves) and peat (accumulations of plant remains, usually in swamps where decay is very slow) contain many somewhat coarse fragments of leaves and twigs. Well-decayed humus is exceedingly fine, and it dissolves or becomes somewhat jelly-like when soaked in water.

Soil particles are usually grouped together. If they are separate and free to move about one another, the soil is loose. But it is seldom, except in the coarsest sand, that the individual particles are entirely separate. In most soils they stick together in groups, forming granules of various sizes. When the granules are large, the soil is coarse grained and not in good physical condition for the growth of plants. When the granules are of rather small size, the soil has a crumb structure favorable to the growth of roots.

Soils like sand, that are composed chiefly of coarse particles, are *loose*. Soils like clay, that are made up chiefly of fine particles, often become *hard* and *compact*.

Importance of physical condition of the soil. In a loose soil the roots easily make their way, and the root

Figs. 37 and 38. Spading by the trench method. The gardener scrapes the manure from the unspaded ground into the trench. Then he turns another strip, throwing it forward, and thus completely covers the manure to a depth of several inches. Weeds and grass may be covered in the same way.

hairs are able to push in among the soil granules and particles. But a hard, compact soil may be as difficult for the tiny roots to penetrate as solid rock. In such a compact soil, moreover, there are no spaces (or only small places) between the soil particles for air, and air is necessary for the roots as well as for the other parts of the plant (pages 32 and 51).

Land that has not been in cultivation recently is often hard and compact. This is especially true of the soils of backyard plots, vacant lots that have been much trampled over, and areas that have been poorly drained. The particles are pressed together, and the air spaces are squeezed out. No gardener would think of planting seed in such a soil without first preparing it by tillage.

But even a well-tilled soil tends to become compact from one season to another. It is constantly settling and becoming more solid. If one tramples much about the garden, the soil will become more compact, as may readily be noted from the condition in the paths.

Keeping the soil in good condition. Plowing and spading are the chief means of getting and keeping the soil in good condition. When possible, large gardens should be plowed, but most smaller gardens must be spaded. The best tool for this work is a four-tined spading fork.

In spading, most good gardeners follow the trench or furrow method. The soil is dug to a depth of at least 6 inches, turned over, and thrown forward, leaving a trench into which the next strip of soil is thrown. Manure, sods, leaves, and other coarse vegetable materials can be placed in the trench and well covered with earth; but it is best to spade the coarser materials under only in autumn. Special pains should be taken to pulverize thoroughly all the soil to the depth spaded. If it turns over in large lumps, these should be broken up by hammer-like blows of the fork or with the rake. It pays to do this work well.

Plowing or spading in autumn, as well as in spring, is advisable for all soils that tend to be compact or to be lumpy. The soil is left in the rough, with no attempt to take or level it down to a smooth surface. The action of the frost on the exposed lumps gives a finer crumb structure.

The gardener can also improve the physical condition of soils by the addition of certain materials. Heavy clay soils are benefited by addition of coarse vegetable matter, as poorly rotted manure, leaves, and grass clippings. It is well to add these in autumn so that the tillage in the following spring will mix them well with the soil. The addition of sand or lime will also make compact and lumpy soils more finely granular. Sandy soils tend to be so loose that they dry out too readily; this condition is improved by the addition of well-rotted humus and manure.

Careful treatment required for clay soil. Clay soils tend to become compact and to break up into coarse granules or clods when tilled. If such a soil is too dry when spaded, it is lumpy. If it is too wet, it will be made lumpy. No soil should be spaded except when it is dry enough to crumble readily when rolled in the hands. An easy way to test this is to squeeze a small handful of the soil into the form of a ball, quite as one makes a snowball (Fig. 39). If it sticks together in a ball and

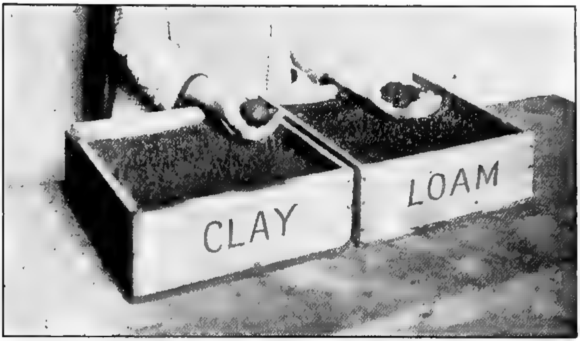


FIG. 39. The clay soil is easily made into a ball, while the loam falls apart. This shows that the loam is in good condition for working, and that the clay is too wet.

leaves the imprint of the hand upon it, then it is too wet for working. But if, on being released, it crumbles and falls apart, it is in suitable condition for working. By spading at the right time and in the right manner the physical condition of clay soils can be much improved.

The best garden soil. The best soil for the garden from the standpoint of its physical condition is a mixture of (1) the remains of plants (humus), (2) sand of various sizes, and (3) silt or clay, with no one of these in excess.

Such soil is called *loam.* It tends to remain year after year with the particles arranged loosely in fine granules. It is easily kept in this condition by tillage. Its physical condition enables the fine fibrous roots of plants to penetrate it easily. But repeated tillage, the addition of lime if it is needed, and supplying humus in manure and compost (page 65) will in a few years do much to improve the physical condition of any soil.

FIG. 40. Spreading manure over the garden. The coarse lumps should be broken up and the material spread evenly. Many gardeners prefer putting the manure into the trench direct and spading it under, instead of scattering it over the surface of the soil.

SOIL FERTILITY

The soil is more than a place for the roots of plants to grow. It supplies water and raw food materials on which the plant lives. *It is itself* raw food material for plants, as plants actually take into themselves certain compounds contained in the soil and change these materials into substances which build the plants up. A rich soil is one that supplies in large amounts the materials that the plant needs. Of these, aside from water, the ones that are most often lacking in sufficient amounts are *nitrogen*, *potassium*, *phosphorus*, and lime.

The food materials are constantly being removed from a cultivated soil in the crops harvested, and are also being lost in the drainage water. Therefore it is often necessary to furnish new supplies of these materials to keep a soil from becoming poorer and less productive. They may be added to the soil as manures, compost, or commercial fertilizers; and it is often advisable that these should be liberally supplied.

Manures. The best fertilizers for gardens are manures. A ton of the usual quality of stable manure that has not been exposed to the weather contains 8.3 pounds of potassium (or 10 pounds of potash), 10 pounds of nitrogen, and 3 pounds of phosphorus (or 5 pounds of phosphoric acid), which have a combined value of about $3.00. Besides supplying these foods, manure improves the physical condition of soil by the humus which it contains. A ton of manure will cover about 4 square rods of area. As stable manure is deficient in phosphorus, it is advisable to add about 2½ pounds of acid phosphate to this area.

Coarse manure may be applied in autumn and plowed or spaded under, but there will be some loss of its substances in the soil water. Well-rotted manures and rich, readily soluble manures, like poultry manure, should be supplied at the time of spading in spring. These may be plowed or spaded in, or a part may be spread on the surface after the spading is done, and raked into the uppermost layers of the soil.

Poultry manure can often be secured by the gardener. It is the richest in nitrogen of all farm manures; but this nitrogen is easily lost by decomposition, particularly during warm weather, or if the manure is subject to leaching. To conserve its materials and use them to the best advantage, the following rules should be observed:

The poultry manure should be dried quickly and kept so until used. *Wood ashes should never be mixed with manures, and especially with poultry manure*, as they

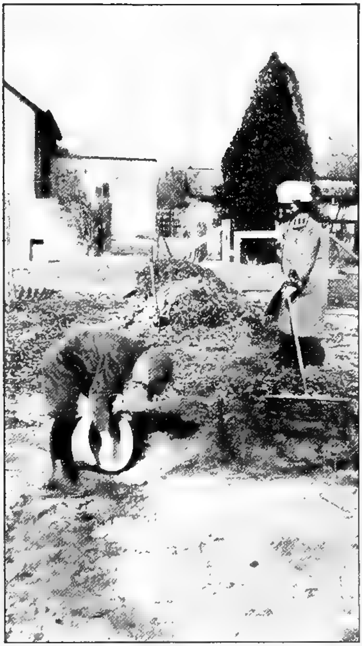


FIG. 41. Refuse from the garden should be made into compost to enrich the soil. In the photograph above, which was taken in the autumn, lime is being spread over the garden to kill insects and to "sweeten" the soil for the next season.

cause chemical changes which lead to the loss of nitrogen. This will also occur if lime is used to "sweeten" the dropping boards under the roost. Dry dirt, sand, peat, land plaster, or sifted coal ashes should be used instead. These absorb liquids and help to dry the manure.

The dropping boards should be cleaned frequently and the accumulated manure spread out in a dry place, or stored in boxes or barrels and kept away from rain until the soil is plowed or spaded in spring.

As poultry manure is relatively much richer in nitrogen than in phosphorus or potash, it is good practice to add to every 10 pounds of the fresh manure 4 pounds of acid phosphate and 2 pounds of kainite (a mineral containing about 12 per cent potash) together with coal ashes, dry muck, or other absorbents. These may be spread on the dropping boards, and the resulting mixture stored dry until used.

Poultry manure is so rich that it will injure plants if applied thickly. The hard, rounded balls should be broken up and pulverized. This may be done by spreading out the dry mixed product on a board platform or a walk and breaking up the lumps with strokes of the back of a spade. As a rule the manure should be spaded into the soil just before planting of seed.

FIG. 42. A Long Island picture showing how the soil is "trenched" and humus added. Two trenches are dug about 3 feet apart and then filled with manure and soil in alternate layers. Then another set of two trenches is dug, the first one between the two shown in the picture, and the second just beyond the last trench filled. This process is repeated until the whole garden has been covered. The soil is improved in three ways by this method: first, humus is added; second, the soil from below is brought to the surface; and third, the soil is made deeper, giving the roots more space for growth.

Compost. Well-rotted vegetable matter is called *compost.* It may be made from manure which is placed in flat-topped piles so as to absorb much rainfall and hasten rotting. If necessary, water can be added to keep the mass moist. If it is frequently forked over and kept moist, it will rot rapidly without "burning." Layers of sod, dry soil, or peat may be added to absorb the liquid materials.

Compost may be made also from the vegetable wastes of the kitchen that decay readily, from weeds, grass clippings from the lawn, leaves in autumn, and other vegetable matter of any kind. These should all be saved and composted either with manure or separately. Good compost is very valuable in forcing and growing transplanted seedlings in flats in greenhouses, hotbeds, and cold frames, as well as for enriching the soil of the garden.[1] Every garden should have a compost pile. Care should be taken *not to add to compost diseased or insect-infested plants*, for this may facilitate the spread of fungous diseases or insect pests.

Commercial fertilizers. A commercial fertilizer furnishes for the use of plants nitrogen, phosphorus, and potassium. Nitrogen is usually obtained in sodium nitrate, ammonium sulfate, and in " tankage " (the refuse of slaughterhouses). Phosphorus is usually obtained from tankage and from acid phosphate, which is made by treating rock containing phosphates with sulfuric acid. Potassium is obtained mostly from potassium sulfate and potassium chlorid, both of which are mined from the earth.

A fertilizer that supplies all of the three elements, nitrogen, phosphorus, and potassium, is called a " complete " or " general " fertilizer; one that supplies only one or two of these is called an " incomplete " or " special " fertilizer.

A good general fertilizer for garden crops should contain in a form that plants can use, by guaranteed

[1] Compost should not be used for seed beds or in seed pans, as it is too rich for young seedlings.

analysis, about 4 per cent nitrogen, 8 per cent phosphoric acid, and 10 per cent potash. Such a fertilizer may be applied at the rate of about 3 to 5 pounds to every 100 square feet of area.

The following mixture, in accordance with the proportions just given, has been recommended[1] as best for general garden crops:

Sodium nitrate	125 lb.,	yielding 20 lb. nitrogen
Ammonium sulfate	100 lb.,	yielding 20 lb. nitrogen
Tankage	600 lb.,	yielding 40 lb. nitrogen and 54 lb. phosphoric acid
Acid phosphate	775 lb.,	yielding 109 lb. phosphoric acid
Potassium sulfate or potassium chlorid	400 lb.,	yielding 200 lb. potash
	2000 lb.	(total weight)

This mixture is used at the rate of about 1000 pounds to an acre, or about 2½ pounds to 100 square feet of area; but on small home gardens as many as 5 pounds to 100 square feet of area may profitably be used.

Such a fertilizer may be bought with the different substances mixed together, or the gardener may buy the materials separately and mix them for himself. One pound of sodium nitrate, 1 pound of potassium sulfate, and 3 pounds of acid phosphate, mixed thoroughly, will make up an amount sufficient for use on an area of 100 square feet. By coöperative buying the members of a garden class or club can often save money on the fertilizer that they use.

Many soils are deficient in phosphorus. As manure is also deficient in this element, acid phosphate should

[1] Van Slyke, *Fertilizers and Crops*.

be added when manure is used on such a soil. Wood ashes are rich in potassium, and whenever they are available they may be applied directly to the soil at the rate of 10 pounds to every 100 square feet. They should be previously stored in such a manner that leaching is prevented.

Soils vary greatly in character, even in different parts of the same garden. It is often advisable to obtain from the state experiment station or from the county agricultural supervisor special information regarding the particular needs of a soil, especially if one must depend upon commercial fertilizers.

Lime for acid soils. Most garden crops will not grow well in an acid soil. In humid regions, especially, soils tend to become acid. Lime and other substances that keep the soil " sweet " are lost in the drainage water, and the addition of humus and the decay of vegetable matter also increase soil acidity.

The acids in the soil can be changed by the use of lime. Finely pulverized limestone or air-slaked or water-slaked (hydrated) lime are best for sweetening soils. Never use quicklime unless it has been slaked, as it is strongly caustic and will " burn up " the humus in the soil. Do not spread lime in the row at the time seed is sown, as excess of lime in contact with roots is injurious.

Water-slaked or hydrated lime is widely used in making plaster mortar and can usually be bought in small quantities. From 5 to 10 pounds of ground limestone, or half as much of hydrated lime, may be spread on an area of 100 square feet. Clay soils require more lime than

FIG. 43. Lime should be applied when no wind is blowing. Even a mild breeze will carry much of the lime away and prevent an even distribution over the surface.

sandy soils. Lime should not be plowed or spaded under, either in autumn or in spring, but should be scattered over the surface and thoroughly raked in shortly before planting. One application every three years should be sufficient.

Other benefits of lime. Small amounts of the principal elements in lime (calcium and magnesium) are used by plants in building up their bodies, and these elements combine with decayed organic material to form nitrates, which the plants take in and use as the source of their nitrogen. Lime in soils also leads to chemical changes which make it easier for plants to secure the potassium and phosphorus in rock particles. Lime improves the physical condition of the heavy clay soils by making

FIG. 44. Effect of lime on the growth of roots. These Swiss chard plants were planted at the same time and each had the same growing conditions, except that lime was added to the acid soil in which the plant at the left was grown.

them finely granular. It tends to break up compact, coarsely lumpy soils. Finally, lime in soil increases the activity of certain bacteria which cause organic matter to decay and break down into plant foods.

Thus lime, both directly and indirectly, benefits garden plants in many ways, and its moderate application will improve most garden soils.

A rich soil needed for the garden. Often the home vegetable garden is small and the main aim is to produce as much food as possible from it. A very fertile soil is necessary for this kind of intensive gardening; for it is a well-known fact that many soils that will produce fair field crops will yield only meager crops of certain vegetables. This is largely because most garden crops are heavy feeders, requiring especially large amounts of nitrogen and potassium. To yield abundantly they must grow on a soil that supplies them plentifully with these materials.

The excellent qualities of garden vegetables also depend upon a rapid growth that can take place only in a rich soil. Unless thus grown, salad plants like lettuce, Swiss chard, and celery will be of poor quality; root crops like radishes, turnips, and beets will be small, woody, and of poor flavor; and the quality of other crops likewise will be poor.

Proper tillage, good drainage, the repeated addition of humus, manures, and other fertilizers, and the application of lime will in a few years improve almost any soil until it will produce excellent vegetables in abundance. And to have a garden that really pays, we must do this; for gardening is more expensive for a given area in cost of seed and in labor than is agriculture.

Questions

How are soils formed? What is humus? About how many particles are there in an ounce of coarse sand? in an ounce of fine clay? What are soil granules? What size are the granules in a soil that is favorable for the growth of plants? What kind of soil is likely to become compact?

Why is it important that a soil be loose? How may soil be kept in good condition? What soils require most careful treatment? Why? How can we determine if a soil is dry enough for working? What is the best kind of soil for a garden? In what sense is soil itself raw food for plants? What substances needed by plants are most often lacking in soils?

In what ways do manures improve soils? Why must special care be taken when poultry manure is used? What is compost? How is it made?

What are commercial fertilizers? How do they benefit crops? How does lime improve soils? When and how should it be applied? Why is an especially rich soil needed in a garden?

Things to Do and Observe

1. *To observe how soil is made.* Search in road cuts, along river banks, and other places where rock is exposed. Note that in some of these places the compact rocks are crumbling into the small particles that make soil.

2. *To observe the formation of humus.* Examine the surface soil in a forest, or if this cannot be done, examine a compost heap. Note that this soil contains parts of plants in various stages of decay. Observe also its color and texture. What is the color of soils that lack humus?

3. *To observe soil particles and granules.* Crush and examine, first with the eye and then with a hand lens, dry, finely pulverized samples of various soils (clay, humus, sand, and loam). In which are the particles or granules largest? smallest? Compare as to uniformity in the size of the granules.

4. *To show the effect of working soils when they are too wet.* Secure some dry, finely powdered clay or soil in which clay predominates, and two large shallow dishes or pans. Place one quart of the clay in the first dish, flood with water and stir, leaving the clay in irregular, sticky masses.

Place the same amount of clay soil in the second dish, add the same amount of water as was added to the first dish, but do not stir.

Allow the soil in the two dishes to become quite dry. Note that the soil that was stirred is in hard lumps which do not readily break up into granules. Is the soil in the second dish more easily cultivated?

This experiment shows how particles of clay soil may become grouped into large lumps if worked before the excess of water has dried out. Why is a soil of coarse lumps unsuited for planting seeds and growing crops? What should the gardener do to such a soil?

Repeat the above experiment, using first sand and then loam. Are these soils more easily cultivated when wet than is a clay soil?

5. *To determine when a garden soil is dry enough for cultivation.* Fill a flat two-thirds full of clay soil, another with the same amount of sand, and a third with loam. Flood each to the top of the flat with water. Allow the excess of water to drain off through the cracks in the bottom of the flat. Test each soil, as described

on page 60, to determine if it is ready for tillage. Repeat the test at intervals of a few hours. Which becomes ready for tillage first? which last? Make similar tests in the garden before beginning the work of spading or of surface tillage after a rain.

6. *To test soils for acidity.* Obtain a few strips of blue litmus paper. Dig up some of the soil to be tested and place it in a pan. Then insert three or four pieces of the litmus paper in the soil, making sure that the soil particles are pressed firmly against the paper. Examine one of the strips at intervals of several minutes, or until one of them has turned red. The red color shows the presence of acid. If at the end of half an hour the litmus paper shows no change of color, the soil is free from acids.

7. *To solve a few of the gardener's problems in supplying commercial fertilizer to the soil.* Work on the following exercises until you are sure that you could solve similar problems in your own garden.

A. A garden plot is 40 feet wide and 50 feet long. How many pounds of general commercial fertilizer will the gardener need if he desires to supply 5 pounds of the fertilizer to every 100 square feet of the garden?

B. If a gardener wishes to make 100 pounds of the fertilizer mentioned on page 67, how many pounds of each of the ingredients should be purchased? (The quantities given on the page just referred to will make 2000 pounds of fertilizer.) What part of 2000 is 100? Therefore, what part of the total amount of each ingredient given for the 2000 pounds is needed for 100 pounds?

C. A gardener can obtain only (1) sodium nitrate, (2) acid phosphate, and (3) potassium sulfate. He wishes to purchase enough of each to make 100 pounds of a mixed fertilizer yielding $3\frac{1}{2}$ per cent nitrogen, 8 per cent phosphoric acid, and 10 per cent potash. Find the amount of each ingredient needed, as follows:

(1) There should be enough sodium nitrate in the 100 pounds to yield $3\frac{1}{2}$ pounds of nitrogen. Sodium nitrate is 15 per cent nitrogen; one pound has $\frac{15}{100}$ pounds of nitrogen; therefore, it will require as many pounds of sodium nitrate as $\frac{15}{100}$ is contained in $3\frac{1}{2}$. What is this amount?

(2) Calculate the number of pounds of phosphoric acid required. (Acid phosphate is about 14 per cent phosphoric acid.) How many pounds of the acid phosphate are therefore needed to supply the amount of phosphoric acid required?

(3) A pound of potassium sulfate is 54 per cent potash. How many pounds of potassium sulfate are needed to supply the potash required?

(4) Add the three amounts (or the amounts nearest the next even number for any that are not even). If the total is less than 100 pounds, the difference indicates the amount of dry sand or earth that is to be included in the mixture.

D. Is it possible to make a mixture of sodium nitrate, acid phosphate, and potassium sulfate that will contain 8 per cent nitrogen, 10 per cent phosphoric acid, and 15 per cent potash? (Work out this problem, basing your calculation on the facts learned in the previous problems. Determine the amount necessary for each ingredient.)

CHAPTER SEVEN

WATER AND THE PLANT

The thirsty Earth soaks up the rain,
And drinks and gaps for drink again;
The plants suck in the Earth, and are
With constant drinking fresh and fair.

ABRAHAM COWLEY

WATER forms a large part of a living plant. Lettuce and various root crops, for example, are nine-tenths water. The living matter of the cells is bathed in it, and the whole structure of a plant, from the finest rootlets to the most delicate tissues in the leaves, is more or less filled with it. For good growth, garden plants require large amounts of water, and the gardener is interested in knowing how this may be provided for them.

How water is used by a plant. All the various mineral substances needed by the plant can be taken in only when they are dissolved in water. They are all obtained from the water that is in the soil. Furthermore, everything that is moved about inside the plant is carried in water; only minerals and foods that are dissolved in water can pass from one part of the plant to another.

Great quantities of water are evaporated (transpired) from the leaves of plants. For every pound of dry material in a mature plant, 500 pounds of water have passed through that plant during its life. An acre of thrifty vegetables in a single season uses 1000 tons of water, which is equal to about 9 inches of rainfall over the acre. A large sunflower in a single day of midsummer transpires more than a pint of water.

Fig. 45. A mustard seedling soon after germinating on a blotter. Note the delicate root hairs.

These facts explain why plants quickly suffer if they are not provided with a continuous and abundant supply of water.

How roots are adapted for work of collecting water. The roots are the water-gathering organs of the plant. To gain an idea of how well these organs are adapted to their work, germinate some radish seeds on moist blotting paper and examine the roots of the seedlings as they grow.

The young growing roots are very small, brittle, and tender, and they quickly dry out when exposed to the air. At first there is only a primary or first root, which ends in a blunt point. It grows rapidly in length, and side branches soon develop which are quite like the tip of the older root.

Thus rootlet after rootlet appears until there is a much-branched system with many growing ends. As long as the plant lives and is active, the root system continues to branch and send out a mass of young rootlets. When their limit of depth and breadth is reached, branches continue to fill in the space between with a network of the fine roots.

FIG. 46. Young radish seedling with soil clinging to root hairs. The root hairs penetrate among the soil particles and drain off the water from them.

A short distance behind the tip of a rootlet there is a growth somewhat resembling cotton fibers. If we look at this with a reading glass or a simple pocket magnifying glass, we find that this is composed of delicate hair-like outgrowths from the root itself. Each of these root hairs is a slender tube that has grown out from the side of a cell. It is a rod-shaped structure, closed like a finger of a glove at its outer end, and by its growth it thrusts itself in among the soil particles and absorbs water and mineral compounds in solution. In this way the absorbing surface of the rootlet is enormously greater than if no root hairs were developed.

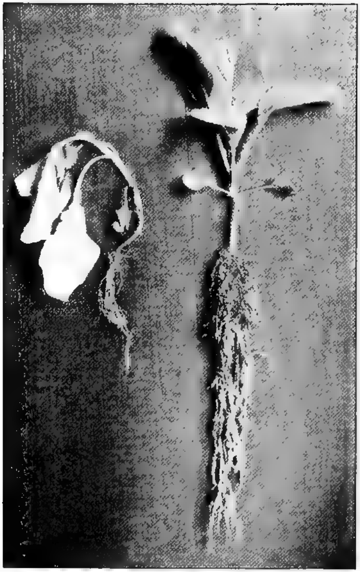


Fig. 47. A seedling carelessly pulled wilts much faster than one carefully dug up. The plant at the left wilted rapidly because many of its roots were broken off and those remaining were unprotected by soil particles. The seedling at the right was carefully lifted from the soil at the same time; it will remain unwilted much longer than the other one.

Root hairs live for only two or three days. They die away on the older parts of the rootlet, and new ones are all the time developing just back of the growing root tips. This habit makes it necessary for the rootlets to keep on growing if the plant is to be supplied with water.

What happens when a plant wilts. When a plant has plenty of water, the cells are well filled and rounded out, so that they press tightly against one another and the whole plant stands up firm and strong. If the plant lacks water, the cells are only partly filled and the leaves and other parts of the plant wilt and droop. In this condition, to a great extent, growth and the manufacture of food stop; and if a garden plant remains wilted continuously for two or three days and nights, it generally dies.

It does not take a plant long to wilt if it is pulled and left in the open air. It wilts just as quickly while standing in the garden if a continuous supply of water does not flow into it through the roots. When insects (such as the squash borer) burrow into stems and cut off and eat out the vessels that carry water upward, the plant soon wilts and may die (page 330). The clubroot disease of cabbage (page 289) often interferes with the work of the roots to such an extent that the infested plant wilts during the day and seldom grows up to be a good plant. The cucumber wilt is caused by a bacterium that enters the vessels and by its growth interferes with the ascent of water, which soon causes the plants to wilt and die. Such injuries as these make evident to us how necessary is the supply of water to all parts of the plant. To replace that which is lost to the air there must be a corresponding intake through the roots from the soil.

Knowing these facts, it is easy to understand why in transplanting seedlings the young plants must not be allowed to become dry; why they need protection from the sun and air until they get a new root system established; why in cultivating and weeding care should be used not to damage the roots of crops; why certain diseases and insect pests must be combated; and why it is so important for the soil of the garden to have in it sufficient water for the growing crops.

Capillary water in the soil. As the water from rain or snow or irrigation sinks through the upper layers of the soil, some of it sticks to the soil particles and is held over and between them as a thin film on their surfaces. This water is called *capillary water*. A good soil holds large amounts of capillary water in this way, and as the root hairs push in among the granules they come in contact with these films and are able to draw water from them for the use of the plant.

Free water in the soil. In a soil that is poorly drained, the water not only forms a coating over the granules, but it may also fill the spaces between them. This water which fills the spaces between the soil particles and granules is called *free water.* It can be drained off. It is not held in the soil, but is free; and like the water in a pond or lake, it will flow to a lower level if it has the opportunity. The roots of garden plants cannot live in a soil that continually retains free water, because the water shuts out the air from between the soil granules. There is not enough air present in such a soil to keep the roots alive, and if a garden site is undrained so that the level of the free water is near the surface, the plants will have only a few shallow roots. These will be able to supply only small amounts of water, and in times of heat and drought the plants will suffer.

Wet soils are cold. Water absorbs more heat in becoming warm than does soil or air. Hence a soil that is saturated with water remains cold longer than a soil containing much air (especially in spring). If the excess of water is removed by drainage, its place is taken by air which may be warmer and which at any rate becomes heated more quickly.

Soils that are naturally " warm " or " early " are those which hold almost no free water in the upper layers. They are usually well-drained soils or soils of loose texture, like a sandy loam. " Cold " or " late " soils are those that retain much water. They are usually fine-grained, like clay, or are poorly drained or poorly tilled.

FIG. 48. On the surface of the stone is a thin film of capillary water; at the bottom is a drop of free water.

Draining a garden. On the farm a well-drained plot can usually be selected for the garden. Cities and villages are usually so well drained that simple ditching about the garden or perhaps across it is all that is needed to carry off the excess water from the soil. But in low-lying land it is sometimes necessary to plant the crops on narrow ridges with open ditches between, in which the free water is exposed to the air for rapid evaporation. Loosening a soil by deep spading and by adding vegetable matter improves the drainage of fine, compact soils.

When the water can be led to a lower level, tiling, or underground drainage, is an excellent means of draining a "wet" garden. For literature on such a special method of treatment one should write to the agricultural college of his state.

It is well to lay out a garden that is inclined to be wet in beds rather than in rows for level culture (page 93).

How to tell if a soil is poorly drained. To determine whether a plot is too wet for garden purposes, sink a hole in the earth with a spade. If free water runs into the hole and stands within 18 inches of the surface, the soil is poorly drained. In such a soil, water will often stand close to the surface or even on the surface after heavy rains. In early spring this condition may do no damage except to delay planting, but if with ordinary rainfall the soil is watersoaked in midsummer, drainage is necessary. The roots of garden crops need to go down deeply into the soil, but they cannot thrive below the level of the free water, which may happen to be near the surface.

In draining a garden, it should be borne in mind that a ditch will remove the free water only when it leads to lower levels, and also that it will remove water only to the level of the bottom of the ditch.

Increasing capillary water in the soil. By tillage and by adding vegetable matter, the gardener can greatly increase the power of the soil to furnish water to the growing crops. A coarse-grained and lumpy soil does not hold much water. It dries out quickly after a rain, and capillary water does not rise into it from lower levels in abundance or with uniformity because of the large and irregular air spaces between the lumps. Good tillage makes such soils more finely granular, so that they can

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FIG. 49. Draining a garden site. Unless the free water is removed from the soil, garden plants cannot grow in it.

take in more of the water that falls and hold more of it as capillary water.

In a fine-grained, compact soil the air spaces between the particles and granules are small. In wet weather these small spaces are readily filled with free water, which is then difficult to drain away. Another deficiency of a compact soil is that much of the water that falls on it runs off without sinking in and being held as capillary water. Plowing and spading break up and loosen compact soils, increasing the air spaces between the granules and making it easier for water to enter and move to lower levels.

Spading under manure and vegetable matter makes a soil looser. Such materials also add to the water-holding power of the soil, for the pieces of decaying plant material hold water like little sponges and give it up to the roots when needed.

Sandy soils hold less water than clay soils. Therefore, well-rotted manure often greatly improves them. Lime loosens a heavy clay soil and makes it more granular, thus improving it for garden use.

Movement of water in the soil. The roots of vigorously growing plants quickly absorb most of the capillary water that is on the soil particles which they touch. But more water creeps to these particles from the surrounding soil or from lower levels. The movement of this water through the soil is quite like that of oil rising through the wick of a burning lamp. Having the soil in good physical condition makes it possible for the water to move easily through it and thus to come within reach of the plant's roots.

A fine, loose condition of the soil also allows the roots to penetrate more deeply and to spread more widely, thus increasing the water supply available to the plant.

Conserving the soil moisture. Water evaporates from the surface of a soil into the air. Then more water rises from below, through capillary action, and this also is lost to the air. Thus in time the soil becomes dried out, and plants often suffer because the water they need has evaporated into the air.

If a mulch of fine manure, straw, or leaves is placed over the soil, the evaporation from the surface is checked, and the soil moisture is conserved; celery, eggplant, Chinese cabbage, endive, and lettuce are benefited by such mulches, especially in dry periods or when grown on dry, sandy soils.

A mulch may also be made of a layer of loose surface soil. If the top inch of soil is raked loose and fine, it quickly dries out, and because its connection with the soil below is somewhat broken, the water does not readily rise into it by capillary action. This loose surface soil, therefore, acts as a covering for the lower soil, keeping the moisture that is in it from being lost to the air. Frequent shallow cultivation of growing crops is very essential to maintain a surface mulch.

Watering the garden. Crops use large amounts of water, and even under the best methods of culture the natural supply may be insufficient for their needs. It is then often advisable to supply water by irrigation. This subject will be discussed in the chapter on "The Care of Growing Crops" (page 207).

Effects of the gardener's work on the supply of soil water. From what we have now learned, it will be understood that garden plants can use only the capillary water of the soil; that free water about roots is harmful to them; and that to fit a soil for garden purposes, the free water must be drained off and the soil made to hold as much capillary water as possible.

Nearly everything the gardener does to the soil affects the water supply in it. Drainage has for its direct aim the removal of free water, which makes it possible for the roots of crops to penetrate deeply. The addition of lime, manure, and compost causes the free water to drain off more quickly and increases the amount of capillary water held in the soil. Plowing and spading also increase the power of the soil to hold capillary water, and one of the reasons for the cultivation of growing crops is to retain the water in the soil for the use of the plants.

The gardener, therefore, in large measure controls the supply of water in the soil. He removes the excess that is harmful; he increases the power of the soil to hold water in suitable form for his plants; he saves or conserves the water present in the soil; and he supplies water when it is needed. By a study of the soil and of the water in it, he can do the things that regulate the water supply to the needs of his crops.

Questions

About what proportion of the entire living plant is composed of water? What are some of the uses of water to a green plant? Give some facts that explain why plants need an abundant and a continuous supply of water.

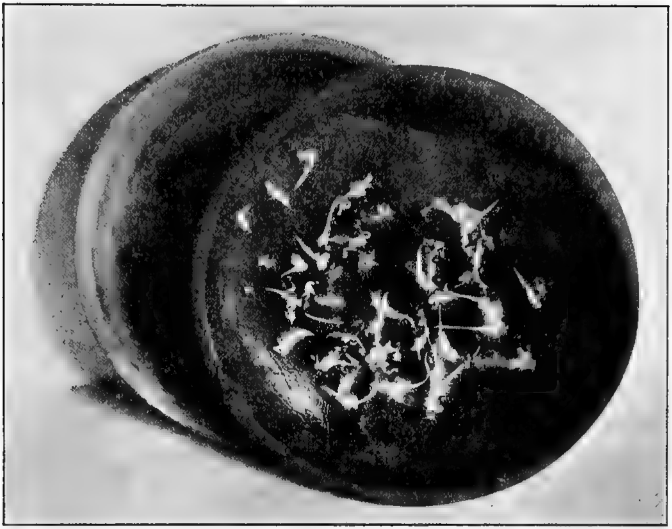

Fig. 50. Seedlings germinating in earthen saucer.

Explain how the roots of a plant develop. How are roots adapted to the work of getting water from soil? What happens when a plant wilts ?

Why must a newly transplanted plant have special care? What is capillary water? free water? Do plants grow best in a soil containing free water or only capillary water? Why? Why do wet soils remain cold longer than a soil that is not so wet?

How can you determine if a soil is poorly drained? How can a gardener increase the water-holding power of a soil? Describe the movement of water in soils. How can the gardener conserve soil moisture?

Things to Do and Observe

1. *To observe root hairs.* Germinate seeds of cabbage or radish on blotters placed between saucers, keeping the blotters moist with capillary water (Fig. 50). (Petri dishes are better than saucers if the school has them.) With a hand lens examine the

root hairs that form, noting their number and size. On what part of the root are they actively growing? On what part are

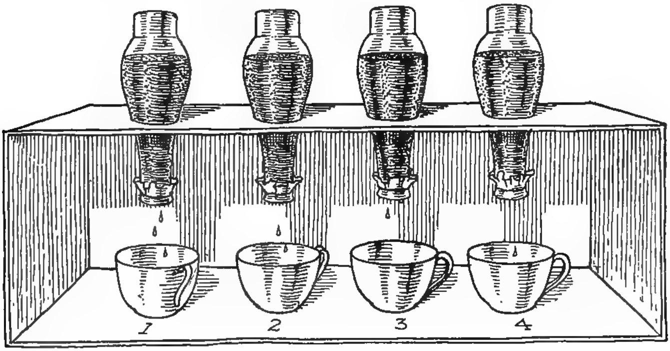

Fig. 51. Experiment to show the power of different soils to hold capillary water.

they dying? Describe a root hair. How do these root hairs increase the total amount of root surface? How does this affect the power of the plant to absorb water?

2. *To show the upward movement of capillary water in soil.* Tie a piece of thin cotton cloth securely over the large end of a lamp chimney. Fill with dry garden soil. Place in a shallow dish containing a pint of water and leave thus until the following day. How high does the free water rise? How high does the capillary water rise? How can it be kept from evaporating from the surface of the soil?

Now carefully lift the chimney with contents, allowing the free water, if there is any, to drain back into the dish. Measure the amount of water left in the dish. How much water has moved up into the soil as capillary water?

During dry weather is there an upward movement of water from the deeper parts of the soil?

3. *To compare the power of different soils to hold capillary water.* Tie thin cotton cloth over the small end of four lamp chimneys. Fill one with sand, one with clay, one with humus, and one with loam (all dry and finely powdered). Arrange as shown in Figure

51. Pour gently and slowly a pint of water into the top of each chimney. The water that drips through is free water; that which is kept has become capillary water. Compare as to time when water begins to drip, length of time the dripping continues, and amount of water retained.

How does the addition of humus affect the water-holding power of sandy soils? How does sand improve a clay soil?

CHAPTER EIGHT

PLANNING THE GARDEN

> Let us sit down by the crackling fire and lay out plans for the year.
>
> *Old Farmer's Almanac*

THE arrangement of every home vegetable garden should be worked out according to a plan made several weeks in advance of the earliest planting dates. This will allow time for buying seed before planting time. The plan should show the kinds of crops to be grown, the relative location of each, and the space to be given to each kind.

Such points as the size of the garden plot, the kind of soil, the drainage, the exposure to sunlight, how the garden is to be cultivated, the local climatic conditions, the particular needs of the crops to be grown, the family tastes and preferences for vegetables, and whether the family will be away during the summer, are all matters to be considered in planning the garden. It will help greatly in deciding what crops should be grown and how much of each it is best to plant, if a definite plan of the garden is made.

Making the plan. In drawing a plan it is best to draw to a scale. This means that the garden itself is first measured and then the plan of it is drawn so that each inch on the plan represents a certain number of feet in the garden.. If the garden is small the plan may be drawn on a scale of 2 feet to the inch; for the moderate-sized garden it is better to use a scale of 4 feet to the inch; and for the very large garden a scale of 8 feet to the inch may be necessary. In this way, by using the divisions on an ordinary ruler (such as ½ inch, ¼ inch,

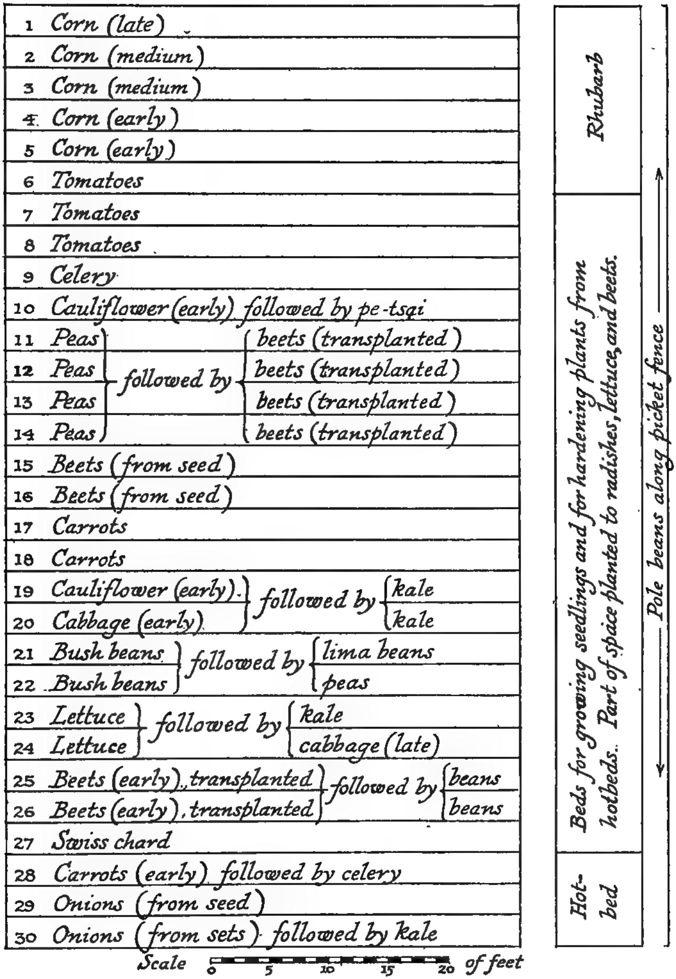

FIG. 52. Plan of a home garden. The ground is kept occupied during the entire season.

Fig. 53. A photograph of the garden the plan of which is shown in Figure 52. With only two seasons' experience the owner has one of the most successful gardens in his community.

or $\frac{1}{8}$ inch) to represent a foot, the plan may be easily drawn and distances on any part of it may be determined at once by merely laying the ruler on the portion to be measured.

Several plans may have to be drawn before the most satisfactory arrangement is found. The final plan should be drawn on heavy cardboard and kept for ready reference. It should show exactly how many rows and how many feet of rows of each variety are to be planted. With such a plan one can determine the amount of seed required for each variety.

A few general directions regarding the making of a garden plan may be given. Tall growing plants, like corn, pole beans, peas on brush or wire, tomatoes trained to stakes, and Jerusalem artichoke should be placed so that they will shade the smaller plants as little as possible. Along a fence or at the north or west side of a garden is a good location for tall plants. They may also be used to good advantage as screens in front of a chicken yard or about a compost pile (Fig. 160). Perennials like rhubarb, asparagus, and strawberries should be grouped at an end of the garden where they least interfere with the work of tillage.

The vegetables that are planted first in spring may be grouped together and the work of spading and planting be done at intervals as later plantings are made.

Planting in rows. Most gardens should be laid out in rows which run the entire length or width of the garden or to necessary paths. If a horse is used in cultivating the garden, the rows should run the long way and be spaced about 2½ to 3 feet apart. When a wheel hoe is used, a width of 12 to 36 inches, according to the crop, is convenient. In small gardens, where the work is all done by hand, the rows may be much closer for many of the smaller growing crops; thus more plants can be grown on a given area. Radishes, for example, may be spaced in rows 6 inches apart, and carrots as close as 8 or 10 inches apart. A distance of 18 inches is very suitable for many crops under hand cultivation.

Planting in beds. When the garden plot is of very small size and the work is all done by hand, the garden may often be laid out in beds to good advantage, as shown in Figure 55. The narrow paths between the beds enable children to walk freely about without injury to the plants. The work of tillage and weeding can be done

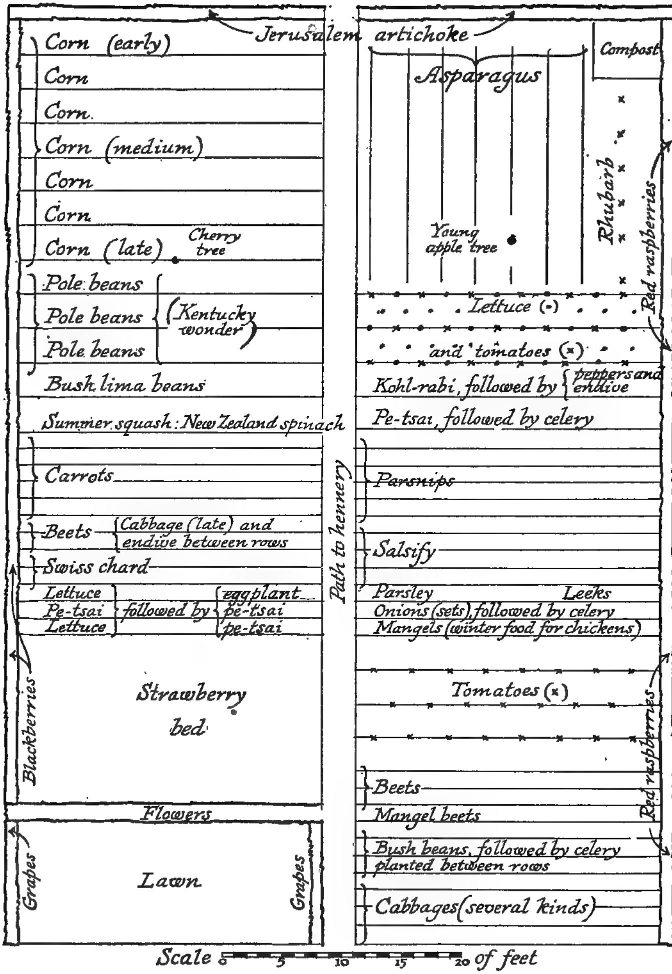

FIG. 54. Plan of author's garden.

from the paths, for all parts of the bed are within easy reach. Walking in the beds among the plants is thus avoided; therefore the soil is not compacted by trampling and it remains much more uniformly loose. When the seeds are planted, one should use a board to walk on.

At planting time the beds should be level with the paths or only slightly rounded above. Walking in the paths soon makes them lower than the beds, and then water will run through them. If the garden is poorly drained, the paths may be arranged to lead to a shallow ditch, dug along one side of the garden so as to lead to lower levels. Excess water is thus carried away after each rain. The garden shown in Figure 55 was laid out in beds chiefly because it needed the drainage that the paths gave.

Special points to plan for. In planning a vegetable garden, one should have especially the three following aims in mind:

(1) To grow different sorts of vegetables which give pleasing variety and a continued and adequate supply of vegetables for the table.

(2) To avoid overplanting of any one crop at one time.

(3) To keep the soil fully occupied and busy in producing crops.

What is meant by these three aims and how the gardener may plan for them will now be discussed briefly.

Planting for variety. The home gardener grows at least several kinds of vegetables. Such standard vegetables as corn, beans, cabbage, and tomatoes are all quite different in the food products that they yield, in their appeal to the taste, in their uses, and in the time of the season when they are ready for the table. By increasing the number of kinds of vegetables grown, greater variety is obtained. Fortunately the number of different vegetables that can readily be grown is large and affords a wide variety of vegetable foods.

Avoiding overplanting. Probably the mistake most often made by the inexperienced gardener is the planting of too much of one variety at one time. If this is done the entire product is likely to be ready for table use at about the same time, and there may be more than can be used, especially if the product is perishable. This results in waste of food, waste of space in the garden, and waste of labor.

To avoid overplanting, either (1) plant less of any one variety at a time, and make *successive* plantings of it on different dates; or (2) plant seed of several varieties which mature at different times. Seed of a single early variety of corn, for example, may be planted at intervals of two weeks; or the seeds of early, medium, and late varieties may all be planted at about the same time in spring.

The later plantings of a vegetable sometimes fail because the summer weather may be unfavorable for the proper growth of the young plants. In a hot, dry summer, late plantings of corn are likely to become dwarfed and yield poorly developed ears. As a rule, successive plantings are most successful on a rich soil that is well supplied with water.

The planting of different varieties of the same vegetable is one of the best ways of obtaining successive crops. It is a good plan to grow a few plants of the

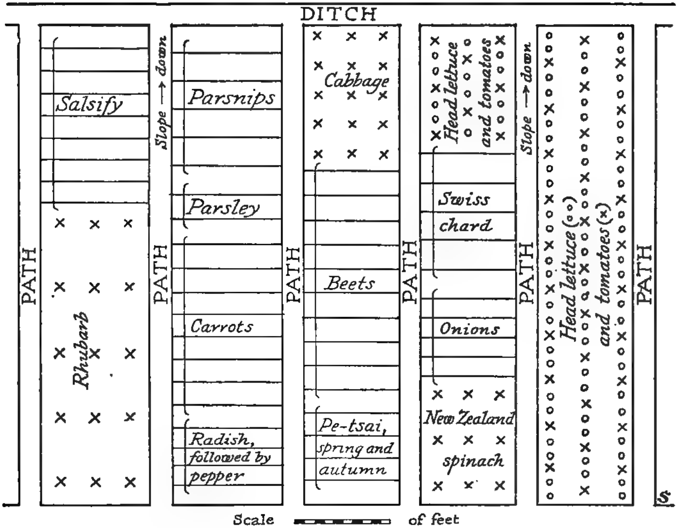

FIG. 55. Plan of a small home vegetable garden arranged for planting in beds. The paths between the beds slope down to a ditch at one side, thus insuring perfect drainage.

very earliest varieties of such crops as peas, beans, carrots, radishes, corn, and tomatoes, even though these are not the best in yield or in flavor. They will furnish food in advance of the main crop, at a time when *any* "new" vegetable is especially relished and when the market prices are high.

In the northern planting zones, as a rule, long-season crops (like corn and tomatoes) are not suited to successive plantings. For such vegetables, the planting of several varieties is the best way to provide variety and avoid overplanting. In the southern sections, successive plantings may be made of the long-season crops. The

FIG. 56. Successive plantings of corn. By repeated plantings it is often possible to have a supply of a vegetable through a long season.

early and late varieties of certain crops, cabbage for example, are best planted at different dates.

The seed catalogues list "novelties" for early and late planting; but care should be taken in selecting such vegetables, especially the early kinds. It is always best to buy seed of standard varieties from reliable firms, for the main crop.

Keeping the soil occupied. In small gardens, vegetables should be kept growing in every bit of the space throughout the garden season. As soon as the yearly crops are removed, others should take their places. This may be accomplished either by *companion cropping* or by *succession cropping*.

Early vegetables may be placed together with slower-growing and later-maturing plants, either in the same row or in alternate rows. This is called *companion cropping*. The early crop is removed before the late crop has reached such a size that it needs all the ground.

Lettuce may thus be grown with tomato plants, as shown in Figures 54 and 55. Both the lettuce and tomato plants may be transplanted to the garden at about the same time, or the lettuce may be planted earlier. The heads of lettuce are gathered about the time that the tomato plants are overshadowing them. Lettuce may thus be grown with peppers and eggplants. Lettuce maturing in 5 weeks may be grown with cabbage that matures in 10 weeks. (See Figure 58.) Radishes and carrots may be sown in alternate rows 6 inches apart; then when the radishes are removed the rows of carrots are left 12 inches apart.

FIG. 57. A follow crop (carrots) planted after lettuce has been removed. Two crops are obtained from the same garden space and they are secured with less labor and expense than if the soil were prepared for each separately.

Many of the short-period vegetables, and especially the early cool-season crops, mature and are removed from the garden in time to grow another crop. This second crop is called a *succession* or *follow crop*. Some of the short-period crops are: radishes, lettuce, peas, early cabbages, spinach, turnips, beets, early carrots,

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FIG. 58. Lettuce and cabbage grown as companion crop. The lettuce will soon be cut, making room for the cabbages.

early potatoes, and even early corn, early beans, and onions from sets. Some of the vegetables that may be planted as follow crops are: beets, carrots, late cabbages, spinach, celery, pe-tsaí, chicory, and endive.

Often the follow crop may be started somewhat before the earlier crop is removed, by planting between the rows. Sweet corn may be planted between rows of peas; pe-tsai, late cabbages, kale, or endive may be set out between rows of early sweet corn about the time the latter is maturing; and celery may be planted between rows of beans, as shown in Figure 54.

As the gardener gains in experience in growing the various garden vegetables, he learns their habits of growth, the length of time required for each to mature, and the space which each needs under the conditions which his garden affords. In the small vegetable garden where space is limited, many schemes of companion and follow cropping can be worked out which will greatly increase the total production.

A little study of the best ways of grouping vegetables for companion and succession crops, as suggested in the paragraphs above, will help the gardener so to plan that overplanting will be avoided. He will then have a pleasing variety of foods, and the soil will be kept busy through the whole growing season. Notes regarding these points and suggestions for improving the garden should be recorded as they come to mind during the growing of crops. Perhaps the notes may be kept on the back of the cardboard on which the plan was drawn. These will aid greatly in making plans for following seasons.

Planning school gardens. What has been said concerning the planning of home gardens and school directed home gardens applies equally to school gardens, especially to demonstration gardens (page 10) and community or grade gardens (page 6). In most school gardens fewer vegetables are grown than in a home garden, and the planning is therefore somewhat simpler.

When the individual plot system with paths between the plots is used, the whole area is laid out like a checkerboard into plots of uniform size with straight paths running entirely across the area (Figs. 2 and 3). Stakes are placed at the corners of the plots and the paths and plots are kept in line throughout the season. The plots are as a rule all planted alike with the rows running the same way and with the different kinds of vegetables in the same relative positions. All this gives uniformity of appearance and makes for order and neatness. When the paths are omitted (Fig. 4), the rows of vegetables run without interruption straight across the entire garden, and stakes are used to indicate the corners of the individual plots.

Questions

Study the plans given in Figures 52 and 54. What is the scale to which these are drawn? How large were the gardens? What crops were grown and how many feet (in rows) were planted to each?

When is it best to plant in rows and when in beds? In planning a vegetable garden, what special points should the gardener have in mind? What are the usual methods of planting to provide for variety? What crops are most likely to be overplanted? How can overplanting be avoided? What are companion crops? Name some and explain why they can be thus grown. What are follow crops? Name some crops that may be thus planted.

Things to Do and Observe

1. *To draw a garden plan.* Measure the garden plot and draw an outline of it to a scale (4 feet to 1 inch is a good scale, unless the garden is unusually large). Make a list of the crops you wish to grow. If there are to be any perennials, decide where they are to be planted; also decide where the tall-growing crops will stand. Determine how many rows can be allowed for each crop, and then complete the plan by drawing the lines for each row. The rows of companion and follow crops may be indicated by dotted lines and the other rows by solid lines.

2. *To observe the arrangement of other gardens.* When visiting other gardens in your neighborhood, note the general plan of arrangement of each garden. Try to determine the good features and the bad features of each plan, and then try to discover how the arrangement might be improved. Note especially whether each gardener is utilizing his garden space as efficiently and economically as possible.

CHAPTER NINE

TOOLS FOR THE GARDEN

> When putting away the tools for winter, lay aside those which need repairs so that they will not be forgotten.
>
> *Old Farmer's Almanac*

In buying the first tools for gardening work, it is best to select the kinds most commonly in use. *Buy only those that are strongly made and of good material.* Poor tools break easily and wear out quickly, and are therefore a source of discouragement. Most hardware stores carry well-made sets of the most important garden tools; especially sets consisting of a hoe, a spade, and a rake. These may be had in small sizes suitable for women and children. Many of the "combination" tools (two or more tools attached to one handle) are poorly made and are so clumsy to use that they are not to be recommended.

Tools for spading. For the work of spading, a fork with four or five flat tines is the best tool. It should be strongly made, and the tines should be of good steel to stand the strain of the work. Even then, care must be used not to break or bend the tines, especially if the ground is stony. An ordinary square or round-pointed spade may be used when sod is to be spaded under; it may also be used for any spading work, but it is harder to force into the soil than a fork, and it does not break up the earth so finely.

The rake. After the spading fork, an iron or steel rake with numerous fine teeth is the most necessary tool in the garden. It is used for making the soil fine after spading and also for cultivating the growing crops. The rake is the best tool for making a good surface mulch on

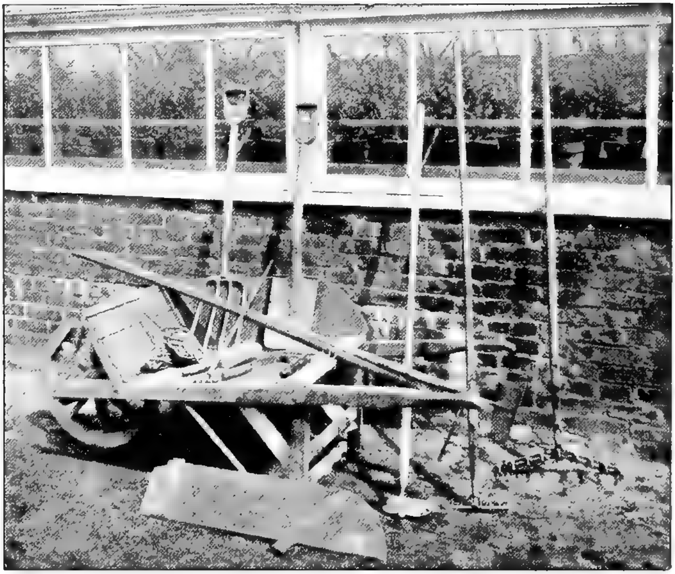


FIG. 59. For a small garden a spading fork, hoe, and rake are all the tools that are necessary. For a large garden, a wheelbarrow and some additional tools are needed. Note the heavy cord for laying out the rows.

the soil (page 85). A child's steel rake, about 6 inches wide, with short, fine teeth, is very useful in covering seeds and in cultivating when crops are growing in rows too close together for the use of the larger garden rake. The smaller rake makes a fine and shallow surface mulch.

Tools and accessories for planting. In laying out the garden for planting, stakes and a line are almost necessary. A hatchet for sharpening and driving stakes is convenient. A trowel is useful in lifting and resetting plants, in making shallow trenches for seed, and in covering seeds after they are sown. A dibble is used in transplanting plants, especially into flats; but a planting peg, equally effective, may easily be made from a 7-inch piece of a broom handle. Whittle one end to a tapering but blunt point, and round off the other end to fit into the hollow of the hand. Pegs of smaller size (Fig. 110) may be made for transplanting very small seedlings.

FIG. 60. A wheel hoe is very useful in a large garden. With it the plants can be cultivated much more rapidly than with a hand hoe or rake.

For laying out and planting in straight rows of even distance apart, a rule or measuring stick and a line and stakes are needed. An old clothesline or a heavy cord long enough to reach across the garden will do. If the garden is laid out in beds, the line should be stretched at each side of the bed and the rows planted at right angles to these. Using a planting board about 8 feet long and 1 foot wide not only keeps the bed from being trampled but also makes it easier to get the rows straight and properly spaced.

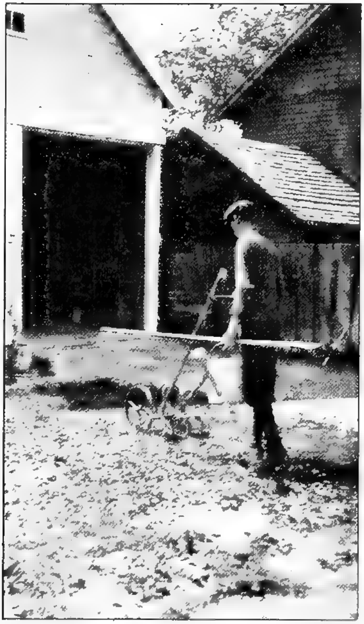


Fig. 61. When the day's work is finished, the tools should be gathered up and put away.

A basket should be used for carrying and keeping in order seed packages, notebook or record with garden plan, and such small tools as trowel and peg.

Tools for cultivating. In cultivating the crops grown in a small-sized garden, a rake is the most valuable tool. Its repeated use to maintain a surface mulch will prevent weeds from starting and keep the garden in good condition. Garden hoes are useful for cutting off and killing weeds that have started to grow, in keeping paths clean, and in making furrows preparatory to seed planting or irrigation. A sharp-pointed hoe of triangular shape, often called the "Warren hoe," is excellent for working in compact ground. A hoe of this kind is especially useful in working among strawberries and other plants that grow in beds or matted rows. The square hoe is probably the one most generally used.

Various sorts of hand weeders and long-handled cultivators, such as the "Norcross" or the "Pull Easy"

States Relations Service

Fig. 62. If the soil sticks to the tools they should be washed before they are put away. They must be wiped dry after washing, so that they will not rust.

adjustable cultivator, are used by many gardeners. Several types of wheel hoes, with cultivator and rake attachments, may be bought. These are especially useful in cultivating large gardens by hand. The various attachments are easily and quickly changed as desired, and the implement is light and easy to use. The machine covers ground rapidly and does efficient work. The single-wheel type, such as is shown in Figure 60, is most commonly used. Except in heavy soils, a boy or girl of fifteen can easily operate this tool.

Care of tools. When not in actual use, all tools should be kept clean and free from moisture and stored in a dry place. In the home each tool should have a definite place. In school gardening each set of tools

Fig. 63. Right and wrong ways of using the spading fork. Study the positions of the hands and feet of the man on the right, and practice until you are sure you can spade correctly.

should be numbered and each child should be allotted a number and be held responsible for the tools corresponding to his number. Rust should never be allowed to form on any tool. If it does, it should be removed by vigorous use of sandpaper.

Perhaps the best place to hang tools is against a wall inside a building. When they are put away for the winter, a coat of heavy oil or oil paint should be applied to the unprotected metal surfaces to prevent rusting. A coating of melted paraffin or of vaseline will protect them if no oil or paint is at hand.

Right and wrong ways of using tools. It will pay the beginner, and often also the more experienced gardener, to make some study regarding the easiest way of using tools. It is not easy to describe on paper the best methods. In hoeing, raking, spading, carrying water, carrying flats, and using the wheel hoe, one should aim to keep the body well balanced and in graceful position so that the tools may be used without undue strain. A few illustrations will perhaps show what is meant.

U. S. D. A.

FIG. 64. The proper way to leave tools in the garden, when not in use. Make it a habit to stick the fork in the ground and to turn the rake and hoe down when they are not in use.

In Figure 63 the student to the left is forcing a spading fork into the ground with the fork pressing against the instep and heel. This position might strain and injure the foot, since it is not intended to carry weight at this point. The hand grasping the end of the handle has the palm downward. The student is pushing against the spade with his body. In lifting the soil, he must step to one side or be put to undue strain in lifting the forkful of earth out and away from the body, and the position of the left hand does not allow him to turn the fork and soil over with ease.

The student at the right is using the ball of the foot to force the spade into the ground. He stands in a position to swing the left hand down to the side quite naturally and thus lift the earth and turn it over with the hands separated at each side of the body, giving excellent leverage, perfect balance of the body, and an easy, swinging motion. His task will not be unduly tiresome, and his work will be effective.

The art of correctly using garden tools can be acquired only by practice, but a practical demonstration by an expert will greatly aid the beginner in getting started right. Some gardeners can use a hoe or rake all day without becoming very tired. Watch such gardeners and learn to handle your tools in the right way.

When such tools as the hoe and rake are laid down in the garden, the cutting edge or teeth should be turned downward. If they are left with edge or teeth upward, children may step or fall upon them and be seriously injured.

Questions

Why is it best to buy only well-made tools for garden work? What are the two most necessary garden tools? What other tools and accessories are useful in the home or school garden? What tools are used for cultivation, and how are they used? How should tools be cared for? Why is it important to learn the right ways of using tools?

Things to Do and Observe

1. *To become familiar with garden tools.* Examine the garden tools displayed in store windows and those owned by your friends. Look for advertisements of them in seed catalogues and in garden and agricultural magazines. Be sure to buy tools suited to your size and age, and to the work you wish to do with them.

2. *To learn to use garden tools.* Make a special effort to learn the easiest and most effective ways of using the various tools. Practice the right methods as explained and illustrated in this chapter. Observe teachers, older students, and experienced gardeners who are using tools.

3. *To learn how to care for tools.* Observe the effect of poor care of tools. Find how gardeners store their tools when not in use. Practice taking good care of your own tools.

CHAPTER TEN

SEEDS FOR THE GARDEN

In France, we are told, they have the finest vegetables in the world, and this is so because they practice the most careful seed selection. And strange to say, in France the children are taught to select and prepare the seeds for the garden.

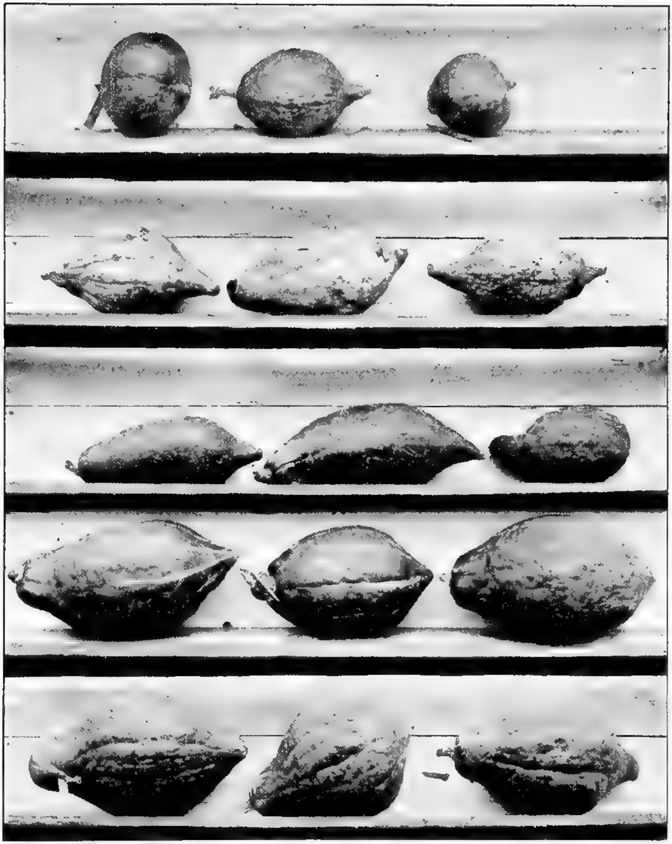
ARTHUR D. CROMWELL

IF a row of radish seeds is planted in the garden some of them will produce good roots earlier than others, while there will be some poor plants which do not produce fleshy roots at all. There are often noticeable differences in the size, shape, and quality of beets grown from the seed of a single packet. Some lettuce plants produce good heads, while others shoot up flower stalks without ever forming a head. Seedlings grown from a packet

J. T. Rosa, Jr., Univ. of Mo.

FIG. 65. Seedlings of tomato, all grown from the same packet of seed, showing difference in vigor. Select fo[r] transplanting only the largest and best plants, for those that are weak in the seedling stage may be weak during their entire lives.

of tomato seed often differ greatly in natural vigor; some are weak, others are strong and vigorous in growth (Fig. 65). Squash plants of the same variety



Richard Wellington

Fig. 66. Best fruits of different plants of Hubbard squash from commercial seed, all grown under the same conditions. The bottom row shows the best type of fruit. The upper three rows are especially undesirable because of their small size and thin flesh. From which ones would you select seed?

often yield fruits that differ very much in size, shape, and quantity and quality of flesh (Fig. 66).

Seeds from good plants are more likely to produce other good plants than are seeds from poor plants. It is important, therefore, for the gardener to have good seeds that have come from the kind of plants that he wishes to raise.

Both parents of a plant important. Selecting seed from good *mother* plants is an old practice. In this way man has long attempted to improve the plants which he has cultivated. In more recent times attention has been paid also to securing a good plant for the *father* or *pollen parent* of the young plant in the seed. Our knowledge of what a seed is and of how it is formed shows why this is necessary.

What a seed is. A seed contains a small plant with very small leaves, stem, and root. This tiny plant is called the *embryo*. Food is usually stored either *around* the embryo or *in its first leaves*. The embryo, together with the food, is inclosed in a tough coat which forms the outside of the seed.

How a seed is produced. To learn how a seed is produced, examine the flowers of the garden bean (although almost any flower may be studied instead). Notice that the bean flower has four different kinds of parts, as follows:

(1) At the outside there are five green leaf-like parts, which cover the rest of the flower in the bud stage. These are called *sepals*.

(2) Next are five somewhat leaf-like but white or colored parts called the *petals*. These are of different

shapes and the lower two are rolled together, appearing like one. In the flowers of many kinds of plants the petals are all alike.

(3) Inclosed within the two lower petals are ten slender, rod-shaped stalks bearing at their summits sac-

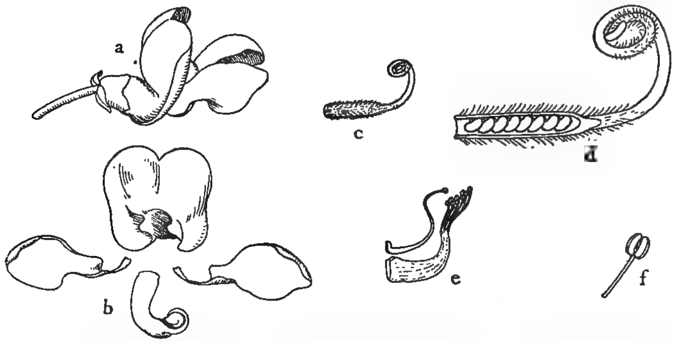


FIG. 67. Parts of a bean flower: *a*, the flower complete; *b*, parts of the corolla; *c*, pistil; *d*, pistil enlarged, with ovary wall cut away showing ovules; *e*, cluster of stamens; *f*, single stamen. All are natural size except *d* and *f*, which are enlarged 2½ times.

like structures. These are called *stamens*, and the sacs are called *anthers*.

(4) In the very center of the flower is a single rod-shaped organ, called a *pistil*, more or less coiled toward the end.

In a few days after a flower of the bean opens, you will observe that all the parts about the pistil wither and fall away. In most of the flowers the pistil remains and grows into a pod containing the seeds.

The anthers and the ovules. If the two lower petals of a fully opened flower of the bean are separated and the stamens examined, it will be seen that the anthers have split open and are shedding a fine, dust-like powder.

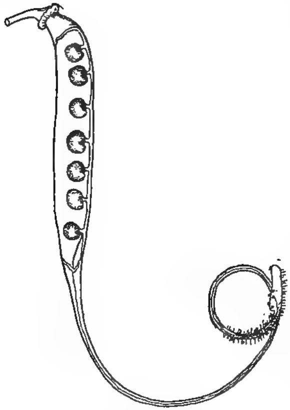


FIG. 68. The pistil of a bean flower at the stage when fertilization occurs; magnified about 5 times. A portion of the outer wall of the ovary is cut away to show the ovules in place. On the stigma and on the brush of hairs near the stigma are several pollen grains, and a black line shows the course of a pollen tube through the pistil to the first ovule.

This is the *pollen*, and under the microscope it is seen to be made up of very small rounded bodies which are called *pollen grains* or *microspores*. The anthers are, therefore, sacs that contain minute spores.

The enlarged base of the pistil is called the *ovary*. If this is slit open and examined, small rounded bodies, much smaller than the anthers, will be found in it. These are the *ovules*. At first each ovule contains a single spore and is thus a spore sac like the anther. The spore, however, is not released but remains within the ovule, and from it there develops a cell called the *egg cell*. In some flowers the ovules are so small that they are hard to see, but in the young fruits the ovules which are becoming seeds are easily seen with the naked eye.

Pollination. In nearly all plants the pistils will wither and drop off unless pollen from the same kind of plant or from closely related plants is placed on the end of each pistil; that is, on the *stigma*.

In some garden plants like corn, cucumber, and squash, the anthers with their pollen and the pistils with their ovules are in separate flowers, and the pollen must be carried by the wind or by insects from the flowers with only stamens to the flowers with only pistils.

In other garden plants (bean, pea, salsify, and tomato are good examples) the stamens and pistils are both present in each flower. But even in these the wind and the insects very often carry pollen from one flower to the pistils of another.

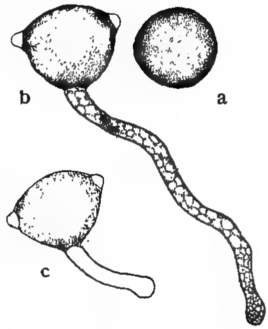


FIG. 69. *a* is a pollen grain, and *b* and *c* show pollen tubes which have developed from grains germinated on sugar-agar. The nucleus of the vegetative cell of the pollen tube is shown near the end of the longer tube; the two male nuclei are shown farther back in the same tube. The grains are here shown 220 times natural size.

The carrying of pollen from the stamens to the pistils is called *pollination*. If the pollen which reaches a pistil is from the same flower or another flower of the same plant, it is *self-pollination*. If it is from a different plant, it is *cross-pollination*.

Fertilization. After the pollen grains have been placed on the *stigma*, a tiny, thread-like tube sprouts out from each pollen grain. These tubes grow downward, making their way among the cells of the pistil, until they reach the sac-like structures (ovules). The pollen tube enters the ovule through a tiny opening that is present in its wall and continues growing until it reaches the egg. There it bursts open at the tip, and a little cell called the *sperm cell*, which was within the tube, unites with the egg cell. This uniting of a sperm and an egg cell is called *fertilization*.

The pollen grain must reach the pistil when both are in the right condition or the pollen will not grow;

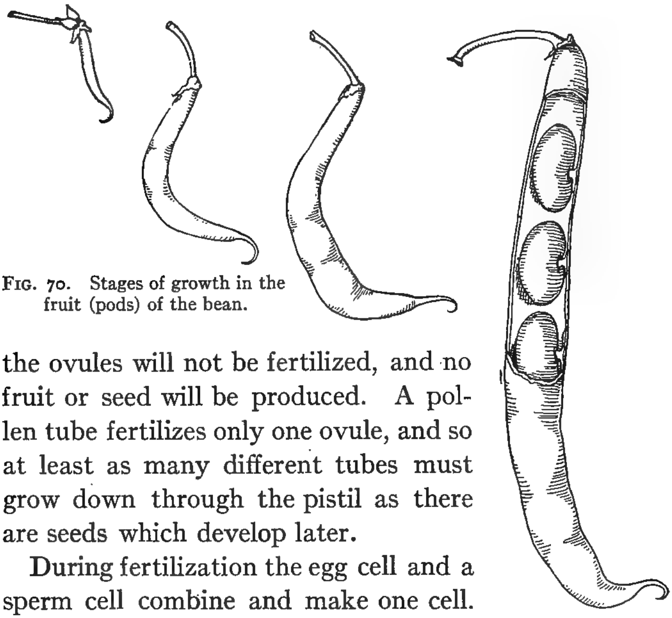


FIG. 70. Stages of growth in the fruit (pods) of the bean.

the ovules will not be fertilized, and no fruit or seed will be produced. A pollen tube fertilizes only one ovule, and so at least as many different tubes must grow down through the pistil as there are seeds which develop later.

During fertilization the egg cell and a sperm cell combine and make one cell. This new cell begins to grow and divide, and this growth is kept up until the embryo is formed. Meanwhile, the ovule develops into the seed, and the pistil enlarges to become the seed pod.

Importance of the pollen parent. The little plants in the seeds borne by a bean plant all have the same mother. But the embryos in two seeds that lie side by side in the same pod may have different plants for pollen parents. If good and poor plants are allowed to bloom together, some of the seeds on even the best plants may have pollen parents that are quite worthless. Because of this fact it is important in seed growing to make sure that *both parents* are good plants.

How new varieties are developed under cultivation. Occasionally plants that are different from the others appear in a crop, giving for example such differences as are shown in the illustration on page 127. Sometimes the difference is due to a natural variation. The new kind of plant simply appears; no one knows the cause of the change in it. Such plants are called *sports*, or *mutants*.

In other cases new plant forms appear because pollen from one kind of plant reaches the pistil and leads to the fertilization of an egg cell of a different kind; then when the seed grows, it produces a plant that may be different from either of its parents. Such plants are called *hybrids*. Gardeners and plant breeders often cross plants to combine the good qualities of both parents in one plant and to cause to appear new qualities that neither parents have.

New varieties are developed from the seeds of these new kinds of plants. All the different kinds of corn are supposed to have come from one ancestor (which may have been a hybrid). Possibly many of the varieties were produced by saving seeds from plants that were different from their parents. In the same way all the different kinds of kidney beans, musk-melons, and tomatoes have been developed by selecting seed from plants that differed from their sister plants.

The various members of the cabbage group illustrate well how gardeners have developed from a common stock

Fig. 71. The two kinds of flowers of a corn plant. At the left is the "tassel," which bears the staminate flowers. At the right is the cluster of female flowers that forms the immature ear. Each thread of this "silk" is a part of a pistil, the portion outside of the husk being stigma. The pollen tubes reach the ovules (which develop into the kernels) by growing down through the silk.

plants that differ markedly from one another. The wild cabbage, now growing on the chalk cliffs of England and elsewhere, is believed to be the ancestor of all the cultivated members of this group. It is a rather scrawny plant with comparatively few leaves, but under cultivation in various climates there have been developed from it:

(1) kohl-rabi with its few leaves and thick, fleshy stem;

(2) kale, with many but separated leaves;

(3) cabbage, with the great bud on the top of the stem developed as a compact head of leaves;

FIG. 72. The two kinds of flowers borne on a summer squash plant; *a*, pistillate flower, complete; *b*, pistillate flower with calyx and corolla removed to show the pistil; *c*, staminate flower, complete; *d*, staminate flower with calyx and corolla removed to show the cluster of stamens.

(4) Brussels sprouts, in which the buds on the sides of the stem develop as small heads; and

(5) cauliflower, in which the first flowering branches are thickened and fleshy.

Selection of seed has given us all these different types of the cabbage group, and further selection has also developed many varieties of each of these different types. Thus there are now many kinds of cabbages, differing in size and shape of the head, in color, and in the length of time required for growth.

Crossing the white scallop pumpkin with the crook-neck pumpkin (usually called summer squash) gives in the second generation many types of fruit, varying in

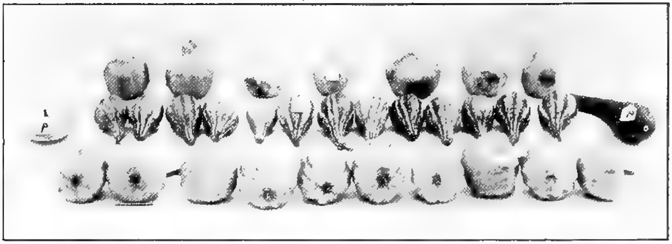


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Fig. 73. Three new varieties of squashes produced by crossing a white scallop summer squash (*P*, at the left side of picture) with a warty, yellow-colored summer crookneck (*P*, at right side). The photograph shows three new varieties that have been produced. The upper row shows a type of short-necked "jug" fruit of medium size with a smooth, cream-colored surface. The middle row shows a longer-necked type of "jug" fruit, somewhat like the crookneck in shape, but *green-striped* and *not warty*. In the lower row the fruits are very thin-fleshed, nearly spherical, cream-colored, and not warty. After the first crossing, the plants were selected and self-bred for five generations, after which some of the new kinds would breed true enough to make new varieties.

shape, size, color, and quality of flesh. Selection and breeding of these hybrids will develop new varieties (Fig. 73).

New varieties are usually first described in the seed catalogues as "novelties." In the course of time novelties may become standard varieties, or they may be discarded because they prove unworthy of cultivation.

How the plant breeder works. In cross-breeding plants, the breeder needs to know for a certainty what the parents are. He, therefore, first selects the two plants that he wishes to cross. Then he applies the pollen from one of them to the pistil of one or more flowers on the other. To prevent self-pollination or stray cross-pollination he may remove the stamens from the flower that is to be pollinated, cover it with a paper bag, or carry out such other measures as may be neces-

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FIG. 74. Result of crossing summer squashes with the field pumpkin. The large cream-colored, pear-shaped fruits in the center of the upper row and the somewhat flattened white or yellow-colored fruits in the bottom row are offspring of a cross between the white scallop and the field pumpkin. The large, elongated, warty fruits in the center row were obtained from among the offspring of a warty "jug" fruit (itself a hybrid) crossed with the field pumpkin.

sary. What he does depends on the kind of flowers borne by the plants.

The plants that grow from the seeds produced in this way are *hybrids*, or cross-breeds. In some cases (for example, in peas and corn) the cross-bred seeds themselves may show that they are hybrids, but for the study of characters like the shape of leaves and the size and color of the fruit, the hybrid plants within the seeds must be grown to maturity.

Usually the first generation of hybrids between two stocks that are not themselves hybrids are all very much alike. They may resemble one parent in one way and the other parent in another way. In general appearance they often seem to be a blend of the two parents.

When the plant breeder saves seed from some of these first-generation hybrid plants, and raises the second hybrid generation, this generation of plants usually shows wide variations. Among these the plant breeder

FIG. 75. Showing how a tomato flower is prepared for hand pollination. *a*, the stage before shedding of pollen when anthers are removed: *b*, flower with stamens removed; pistil fully developed and ready for artificial pollination.

looks for new and valuable kinds. In some respects the plants may be like one or the other of the original parents, but there are often forms that are different in some features from either parent and which when selected may yield new and valuable varieties that will breed true.

In his work the plant breeder self-pollinates the flowers, if possible, of the individuals of the hybrid generations. But in some plants the pollen will not fertilize the ovules on the same plant, or the pollen and pistils mature at different times, so that cross-pollination must be practiced. In studying hybrids, one can obtain a clearer idea of their resemblances to the original parents if attention is given to only one character at a time. The exact way in which a plant breeder goes about his work can be better understood from a study of the cross-breeding of a particular plant, like corn or the tomato.

Cross-breeding corn. Plants of two varieties of corn may readily be crossed, provided they bloom at the same time. Let us suppose that rows of the variety of white corn known as "Stowell's Evergreen" are planted alternately with rows of the black variety called "Black Mexican." The tassels on the plants of the Evergreen can be removed as soon as they appear and before they shed any pollen. The wind will then carry pollen from the Black Mexican to the pistils of the Evergreen, and the seeds in the ears of all the Evergreen corn will be black. Or the cross can be made by removing the tassels of the Black Mexican and allowing the pollen from the Evergreen to fall on the pistils of the Mexican.

Another way is to do the crossing by hand. Stalks bearing two ears may be selected. One ear is used for crossing and the other as a " check " to compare with the hybrids produced. Each ear is properly " bagged," and as the pistils and pollen mature, the bags are removed, the pollinations made, and the bags replaced. The exact method of doing all this is best learned by experiment (page 143).

When the plants (first-generation hybrids) are grown from these seeds, self-pollinations of these may be made. Later generations may be grown from both white and black kernels to determine which breed true. As a rule, it is necessary to cross-pollinate in breeding corn, because the pollen produced by the tassel usually matures before the silk on the same plant is ready to receive it. Self-pollination is easier in the tomato, and in the different varieties of pumpkins, which include the summer squashes.

FIG. 76. An ear of a white variety of sweet corn that grew near a row of Black Mexican corn. Can you explain why some of the grains are white and some are black?

FIG. 77. A cluster of tomato flowers have been bagged to protect them from other pollen.

Cross-breeding tomatoes. Any two varieties of tomatoes may be crossed. If they are planted together in spring, they are certain to have some flowers opening at the same time. For experimental purposes it is well to select two varieties with marked differences, as, for example, a yellow pear-shaped variety and a red variety of ordinary shape.

As the stamens and pistils are both found in the same flower, it is necessary, if one is to be certain of the parentage, to remove the stamens from the flowers that are to be pollinated (see Fig. 75).

Cross-breeding pumpkins. The patty pan, the summer crookneck, and the pumpkin may all be crossed, yielding interesting results as to shape, color, and size of fruits in the second hybrid generation. The stamens and pistils are in separate flowers on the same plant. The pistillate flowers may be recognized in the bud by the enlarged part (ovary) which will later become the fruit.

FIG. 78. Two squashes grown from the same packet of seed purchased for summer crookneck. Both have the characteristic color of the crookneck, but the one on the left is entirely distinct from the crookneck in shape. A variation such as this may be the result of crossing or of sporting and may give rise to new varieties.

To prevent pollination by insects, the pistillate flowers are bagged shortly before they open. As the stems of squash flowers are tender and brittle, special care must be used to prevent injury to them.

Keeping varieties true to kind. After valuable kinds of plants have been produced, the seedsman still has the problem of keeping them true to type. Even the best varieties of vegetables produce some worthless plants and plants not like the parent stock; also many varieties of garden plants cross-fertilize easily. Therefore the well-known and standard varieties must be kept true to kind in seed breeding by preventing accidental cross-pollination between varieties and by discarding, either as seed or pollen parents, the plants that are not true to the variety.

The different varieties of the same species nearly always cross readily. If grown close together, they may bloom at the same time, and insects or the wind are likely to bring about cross-pollination. Different kinds of beets, of radishes, of corn, and of many other plants may be grown at a distance from each other, or the seed

FIG. 79. A portion of the seed trial grounds of a large seed company. Each row is numbered, and a careful record is kept of the growth and yield of the plants. Reliable seed firms spend much money in keeping up the quality of the seeds they sell.

will often be of mixed parentage. When this is the case, they may not be true to varieties.

Most standard varieties are already highly bred and are the result of repeated selection; they appear to have reached their limits as far as the development of desirable qualities is concerned. Variation in such highly bred varieties most often gives rise to poorer plants. The seed breeder watches carefully and pulls up such poor plants (or "rogues," as he calls them), so that they cannot become the parents of his later crops.

Seed growing an important industry. The best seedsmen maintain extensive fields for growing seeds of plants of standard varieties. They also have large growing plots for testing the seeds of other growers and for experimenting in the production of new varieties. Special and often expensive apparatus is used for collecting and cleaning seeds. For many varieties the best seed is produced only in certain localities where the climatic conditions are especially favorable. The average gardener has neither the time, the experience, nor the facilities for the successful seed growing of most garden crops. Because of these facts, he can buy good seeds of most crops cheaper than he can raise them.

Buying seed. The first rule in buying seeds is to *buy those produced by a reliable firm.* The best seed firms take great pains to prevent mixing of different varieties during growth and seed production. They have trial grounds for testing the purity and the quality of seeds before the supply is sold in the market. This makes sure, to a high degree, that the seeds sold in packages will be true to the name on the package. The gardener cannot afford to plant poor seed, even if it is offered as a gift.

The second rule in buying seeds is to *buy only named varieties.* The gardener does not grow simply sweet corn. He grows *Golden Bantam, Country Gentleman,* or some other variety, and he selects these for such qualities as earliness or lateness, size, yield, color, or sweetness. The ordinary seed catalogue affords a choice of several varieties of most garden vegetables. There may be listed as many as 10 varieties of carrots, 25 of cabbages, 30 of sweet corn, 35 of lettuce, and 45 of tomatoes. The gardener must decide what variety or varieties he will grow. Naturally, he hopes to select those that will give the best results in his garden.

The descriptions in the seed catalogues give much valuable information regarding the general characteristics of the varieties listed. For example, the pole and bush varieties of beans, the summer and winter radishes, and the early and late varieties of the garden peas are properly listed and briefly described. One soon learns from the seed catalogues alone, if there is no other source of information, that there are wide differences between the various sorts of the same vegetable. A study of the descriptions in catalogues will help the beginner, before he grows his crops, to judge the merits of different varieties.

Van Evrie Kilpatrick

FIG. 80. Seeds put up especially for New York City school children. The Board of Education contracts with a seed firm for sets of seeds suitable for planting a small garden.

The advice of experienced home gardeners will often be of special value.

The beginner in gardening should choose *standard varieties*. These will usually give the most successful crops. They are standard varieties because by long trial they have been known to give the best crops. If the gardener fails in growing standard sorts, he may be sure that the fault lies in cultural conditions, especially if his neighbors succeed with the same varieties.

As the gardener gains in experience, others besides the standard varieties may be tried with results that may give pleasure as well as profit. Sometimes new varieties are found to be far better than the older varieties in one or more desirable qualities.

Amount of seed needed. Before ordering seeds, the amount of each kind needed should be rather carefully estimated. A single packet of small seeds, such as lettuce, tomato, radish, or cabbage, is sufficient for a small garden. It is well to become familiar with the amount necessary to sow a given area. An ounce of beet seed, for example, will sow a row of about 25 feet. Of the larger seeds, such as bean and corn, a half pint is needed for a row of 50 feet. With a good plan of the garden, one can determine very accurately the quantity of seed needed. No more than this amount should be ordered.

Seeds can be bought cheaper in bulk than in small packets. In a half pound of corn, costing about 25 cents, there are more than three times as many seeds as there are in a 10-cent packet. Any group of persons (a garden club, a school, a class, a troop of Boy Scouts) who are engaged in gardening will find it to their advantage to order in bulk and then divide the seed into packets themselves.

How to produce seeds in the home garden. Good seed of several of the crops grown in the home vegetable garden may be raised by the gardener himself. In growing these seeds, he needs to pay attention to the same matters that the commercial seedsman does. He should aim first to select parents which are true to the variety; next, to prevent cross-pollination between varieties; and finally, to collect and care for the seed properly.

The successful selection of seed and the judgment of parents is least difficult in those plants whose fruits or seeds are used as food. Melons, corn, tomatoes, and beans are in this class. These plants make complete, or almost complete, development as ordinarily grown in the garden. With a little study the best plants may be selected for seed parents. The largest and earliest fruits from best-yielding plants may be saved for their seeds. To insure a good pollen parent for corn, it is an excellent plan to cut out those stalks that bear no ears, and break off, before the pollen is shed, the tassels of the plants that have small ears.

In selection for those plants like the salad plants and the root crops, attention is given especially to the edible parts — leaves, stems, or roots — rather than to the fruits or the seeds. The annuals of this group, especially lettuce and radishes, tend to produce some poor plants which "run to seed" early. These should be pulled up before they blossom. If a few of the *earliest* of the *best* plants are left standing for seed, both parents will be good.

The biennials (plants that blossom in the second year from seed and then die) require more attention than the annuals. In the more northern parts of the United States, to secure seed of the beet, carrot, cabbage, and turnip, the roots must be carefully stored over winter where they will not be frozen, and replanted the following spring. This treatment may be difficult for the average gardener, because he may not have a proper storage place. Plants of salsify and of parsnips, however, can be left in the ground over winter, and in the spring some of the plants with the best roots may be transplanted to a convenient place and left to mature their seeds.

Seed of crosses do not breed true, and if varieties of the same plant grow near each other and bloom at the same time, they usually cross. This is especially true of corn, beets, various members of the cabbage tribe, cucumbers, melons, tomatoes, and lettuce. Thus, cabbage will cross with kohl-rabi; any two sorts of cucumbers may cross; and all sorts of muskmelons can hybridize. But cucumbers will not cross with muskmelons, as is commonly believed. If only one variety of a given vegetable sort is grown in a garden, there is, of course, no chance for crossing with other varieties unless another garden is near by.

Early and late varieties that bloom at different times have no opportunity to cross. The first ears of an early corn, like Golden Bantam or Malcolm, are not usually crossed with late varieties growing in the same garden. In a few of the garden crops, peas and beans

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FIG. 81. A tomato plant marked for seed.

for example, the flowers are so constructed that self-pollination is very general; so there is little chance for crossing, and any seed collected is likely to be of single parentage.

Collection of seed. The best methods of collecting seeds depend chiefly on the nature of the fruit and how the seeds are shed from it. In all cases the aim is to secure fully ripened seeds and to collect them before they are shed broadcast.

The fleshy fruits of the pumpkin, squash, cucumber, and tomato, selected from plants of good quality, should be allowed to ripen fully. They may then be cut open and the seed removed, washed, and spread out on paper or cloth to dry.

The best radish plants should be pulled when the majority of the pods are fully ripe. The best bean plants should be pulled when the pods are about to shed their seeds. In both cases, the whole plant should then be laid in a dry place for a while before the seeds are removed.

Seeds of lettuce are small and shell quickly. The easiest way to collect these seeds is to wait until a large number of the heads are ready to shed their seeds, then pull the plants and insert the top portion in paper bags. Hang them, with the heads down, in a dry place until the seeds have dropped into the bag.

The heads on a plant of salsify ripen and shed seeds at different times, and so the seeds must be collected by hand from each as they ripen. In some localities seeds of the New Zealand spinach ripen and fall to the ground, where they may be very easily collected. Ears of corn selected for seed should be allowed to ripen fully on the plant; then after they are pulled the husks should be stripped back and the ears hung up in a dry place.

The ten plants listed above are those from which seed can most readily be obtained in the ordinary home garden.

Storage of seeds. To keep seeds properly from year to year, or until the next planting time, they must be kept dry and protected from mice and insects. The larger seeds may be kept in cloth or paper bags, but the smaller seeds should be placed in envelopes and each envelope plainly labeled with the name of the variety and the date of collection or purchase. A tin bread box is excellent for the storage of seed; mice cannot get into it, and the ventilator holes allow the air to circulate and keep the seeds dry. Tin cans with close-fitting covers are just as good, but two or three small holes should be made in the cover to give ventilation. Do not store the seed box in the cellar. A dry garret is a better place.

Fumigation for insects. Seeds of corn, peas, and beans are especially likely to be destroyed by insects (larvæ of moths and weevils), and sometimes the eggs of these are laid on or even in seeds about the time they are harvested. It is well, therefore, to gather these seeds as soon as mature and fumigate immediately upon storing them. Also examine the contents of seed boxes occasionally and, if insects are present, fumigate again with carbon bisulfid.

To fumigate, paste paper over the perforated areas of the box and place an open dish containing two tablespoonfuls of liquid carbon bisulfid within the box and on top of the seed; then immediately fasten the cover on tightly.

Caution! Carbon bisulfid is highly inflammable. Its gas readily catches fire if flame of any kind is near. It also affects human beings quite like chloroform. Do not breathe in the fumes; do not take light or flame into the room when fumigation is in progress. It is best to place the box in the open, but the gas forms poorly if the temperature is below 50° F. All fumigation should be done by mature persons who understand fully what care must be taken.

Seed treatment before planting. In a later chapter we shall learn of certain plant diseases that are caused by bacteria or by fungi. These bacteria and the spores of the fungi, in some cases even the strands of fungi, may be present *on* or *in seeds*, ready to grow and feed upon the young plants when they germinate. This condition may be indicated, especially in large seeds like those of the bean, by the presence of blotches or dark-colored sunken or shriveled areas. Seeds showing such infection should never be planted.

It has been found that the proper use of hot water, formaldehyde, and the deadly poison, corrosive sublimate, will often destroy the organisms that are present on or in the seeds. Thus the farmer has learned how to treat the seeds of oats for the smut disease. In much the same way seeds of beans, corn, onions, cucumbers, and beets can be treated for various diseases.

Seed treatment must be done carefully. In the first place there is danger of injuring the seeds; then different kinds of diseases require different kinds of treatment; also, we must remember that some of the chemicals used for this work are deadly poisonous to man. Seed treatment is not to be attempted by children unless under the constant supervision of a fully competent person.

Viability of seeds. When the tiny plant or embryo in the seed begins to grow, we say it "germinates." A seed in which the embryo is alive, so that the seed will germinate, is called "viable." Whether a seed will germinate depends upon (1) the maturity of the seed when collected, (2) the conditions of storage, (3) the age of the seed, and (4) the kind of seed.

If seeds are ripe when collected and if they are properly cared for, the length of time that those of the principal garden crops will remain viable is as follows:

2 years — sweet corn, onion, parsnip, and salsify.

3 years — bean, parsley, and pea.

4 years — carrot, mustard, pepper, and tomato.

5 years — cabbage, cauliflower, kale, kohl-rabi, lettuce,

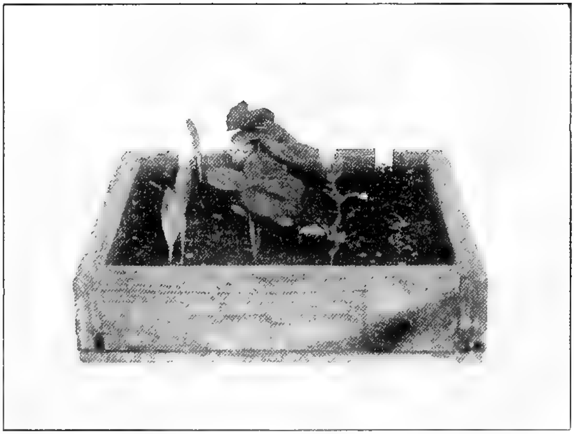

FIG. 82. A germination test of corn and beans. The seed planted in the left half of the box is good; that planted in the right half is poor.

muskmelon, watermelon, okra, radish, pumpkin, squash, spinach, and turnip.

Up to 10 years — cucumber and endive.

Seeds of parsnip, parsley, and celery are always rather poor in viability, and only 60 to 75 per cent of the seed will germinate.

As a rule not every seed in a given lot will germinate, but at least 70 per cent should do so if the seed is in good condition. Beans, peas, corn, radishes, and tomatoes often germinate 95 per cent or more. If less than 70 per cent germinates, some of the plants that do appear are likely to be weak.

Test for germination. One cannot tell for certain from the appearance of seeds whether they will germinate or not. It is therefore a good plan to test the viability of seeds, especially if they are known to be more than one year old. Do this several weeks in advance of the planting dates, so that there will be time to secure a new supply if necessary.

There are several simple methods of testing for germination. One plan is to count out a number of seeds and plant them in garden soil in a seed box, a flat, or a pan. Place this seed pan in a warm room, in a greenhouse, or in a hotbed. Keep the soil properly moist. The number of seeds that germinate will indicate how viable the seeds are.

Another simple method is the blotter test. A blotter is laid on an ordinary plate, seeds are placed on the blotter, and the whole is covered with an inverted plate and kept in a warm room. If the blotter is saturated with water daily, the seeds will receive sufficient moisture for germination. The proportion of embryos that start to grow may readily be observed.

Thus we learn that *when we plant seeds we are placing in the earth little plants which we hope to grow to maturity for the food they afford.* The care which is given in preparing the soil, planting the seed, and rearing the plants determines to a large extent what the quantity and special quality of the food will be. But the *kind of plant and the kind of food it will produce is already determined through its parentage and ancestry.*

We cannot afford to plant poor seed. We can avoid many of the risks regarding quality of seed. We can buy seed of pure varieties or strains from reliable firms, or we can control and select the parentage when producing seed in our own gardens. We can properly store and care for seeds to maintain their natural viability, and we can test samples of seeds to determine if the little plants in them are alive.

Questions

Why is it important for a gardener to plant good seed? What advance has recently been made in selecting seed parents? Describe the structure of a seed. Name the four different parts that you have found in the flower of the bean. What do the anthers contain? Where are the ovules found? What do they become when they mature? What is pollination? Why is it necessary? How is it accomplished? What is self-pollination? cross-pollination? Describe what happens in fertilization. From what does the embryo grow? Why is it important for a seed to have a good pollen parent?

What is a hybrid? How are new varieties of plants obtained? Name a group of vegetables that illustrates the development of a number of varieties from one ancestor. Name the members of this group. What is meant by keeping varieties true to kind? How is this done in seed breeding? Describe briefly the general methods used by the plant breeder in cross-breeding. What can you say of the characteristics of the first generation of hybrids? of the second generation of hybrids? State briefly how corn is cross-bred; tomatoes; pumpkins.

Why should seed be bought of a reliable firm? Why should only named varieties be bought? How may the gardener determine how much seed to order?

From what garden vegetables is seed for planting most easily obtained? Explain some of the things that must be done to insure good seed from corn or from annuals like radish or lettuce. How may seed be obtained from biennial crops, like parsnip and salsify? Under what conditions are different varieties of the same vegetable apt to cross? What garden crops readily cross? Would the pollen of corn lead to fertilization if placed on the pistil of a pumpkin or tomato?

How should seeds be stored in the home? How can insects in seeds be killed? Why are seeds sometimes treated with hot water or formaldehyde before planting? When is a seed "viable"? Name two methods of testing the viability of seeds.

Things to Do and Observe

1. *To study the parts of flowers.* Examine flowers of the different garden plants. Learn to recognize the parts. Which have stamens and pistils present in the same flower? Which have them in different flowers? Do flowers having only stamens produce fruit?

2. *To study pollination.* Watch the insect visitors to flowers. What are they seeking? How do they cause pollination? Observe how the pollen of corn is distributed.

3. *To observe the germination of pollen.* The pollen of some plants will germinate on a drop of sugar solution. Add 1 heaping teaspoonful of cane sugar to 10 teaspoonfuls of water. When the sugar is all dissolved, place a drop of the solution on a clean glass slide. Scatter pollen from a freshly opened anther on the drop. To prevent drop from drying, lay slide across top of a small dish containing water and then invert and place a larger dish so that it incloses both slide and small dish.

Pollen of the paper white narcissus, which may be grown during winter, and of the sweet pea or Easter lily, which may be had at florists', germinate well in this solution. Pollen of the apple may be used in spring, and that of the tomato and beans during summer.

The pollen of many plants germinates poorly if at all on sugar solutions unless *agar* is added to make a jelly.[1] Place ½ teaspoonful of powdered agar (weighing about 1 gram) and 2½ teaspoonfuls of table sugar (weighing about 10 grams) in 20 teaspoonfuls of water (weighing about 100 grams). Heat to gentle boiling until agar and sugar are dissolved. When cool, the mixture is like jelly. To use, gently heat until mixture becomes liquid and then place a drop on a glass slide. The drop soon cools and becomes

[1] Agar-agar may be obtained from any of the many houses which deal in scientific apparatus and supplies; of these Eimer and Amend of New York City may be mentioned.

solid; then the pollen may be scattered over it. Keep in moist air as directed above. The pollen of corn, which does not germinate on sugar and water, germinates readily on the agar-sugar-water mixture.

If the pollen is in good condition, it often germinates in an hour; and the tubes may grow until they are ten times as long as the pollen grains are wide. Examine the germinating pollen under a compound microscope and note the delicate, slender, tube-like plant with its almost colorless granular living material that grows from the pollen grain.

4. *To observe the location of the ovules.* Split a few pistils of peas, beans, squashes, or cucumbers after the corolla has withered and fallen and the fruits have begun to develop. Find the ovules, that are developing into seeds.

5. *To learn varieties of garden vegetables.* Observe closely the individual plants of the various garden crops and learn to judge those that are best and truest to type. In this way learn to distinguish the varieties of each crop.

6. *To learn to recognize the seeds of garden vegetables.* Make a collection of the seeds of garden vegetables, keeping each kind separate in wide-mouth bottles of suitable sizes. Square, screw-top glass jars of one-half-ounce and one-ounce sizes (to be obtained at most drug stores) are excellent for such a collection. Note the characteristics of each kind and how it differs from the others.

Also collect, study, and learn to recognize the seeds of common weeds.

7. *To test the viability of seeds.* Make the two tests for viability mentioned in this chapter, using as many different kinds of seeds as possible. Record the results in your garden notebook.

8. *To demonstrate that pollination is necessary for fruit and seed production.* Select at least four corn plants having ears from which the pistils ("silks") are not quite ready to protrude. Invert over each ear a paper bag (two-pound size), and fit the open end around the ear at a point slightly above the middle; then tie the bag in place with ordinary twine. The end of the ear is thus completely inclosed within the bag, and no pollen can reach the pistils.

Leave the bags undisturbed on half the number of ears until there is no chance that pollination can occur (this will be about 10 days from the date of bagging). Examine the other ears from day to day, carefully replacing bags. When the pistils are protruding in abundance, sprinkle pollen over their ends by shaking it from a cluster of staminate flowers (tassels). This operation should be repeated each day for several days, as the pistils do not all mature at the same time. After about 10 days examine again, and if the ends of the pistils are dry and shriveled, the bags may be removed and each ear tagged or otherwise marked for future identification.

Allow all plants to mature fully. Which ears bear seeds? Which do not?

9. *To learn how to cross-breed corn.* Select a stalk of a white or yellow sweet corn (Stowell's Evergreen will do) bearing two ears, and another of Black Mexican also having two ears. (If stalks bearing two ears are not found, select two stalks of each variety.) "Bag" each ear at the proper time as directed above in 8. Pollinate one ear on each stalk with pollen of the other variety, and the other ear with pollen of the plant itself or from another plant of the same variety. Tag the ears.

Which parent do the hybrid seeds resemble in color? Can you identify hybrid kernels of this cross when borne by the white seed parent? by the black seed parent? Is black or white a dominating character in this cross?

Plant some of these cross-bred seeds from both parents. When the plants flower, bag some of the ears and make self-pollinations as directed in 8. Count the black seeds and the white seeds on each ear. Which are more numerous? What is the ratio? Do all ears give the same ratio? Are there any kernels intermediate in color between black or white, or are there other colors?

10. *To learn how to cross-breed tomatoes.* Select a cluster of tomato flowers in which two or three of the blossoms are freshly opened; that is, when the flowers are open but the yellow petals are not expanded or the stamens cracked open (*a* of Figure 75). First, remove all the stamens with a pair of slender-pointed, curved forceps; to do this, take hold of each stamen near its apex, pull outward with a gentle twist and break the anther from its stem. As the pistils are not yet ready for pollination, they must be left for a while; during this time they should be guarded from stray pollination.

After removing all the stamens of the several flowers, inclose the entire flowering branch in a paper bag of about two-pound size.

Wrap a small handful of cotton about the stem where the mouth of the bag is to be tied, and then tie the bag to the stem (Fig. 77).

In about 2 days the flowers thus prepared may be pollinated. From the plant that has been selected for the pollen parent remove a flower having fully expanded petals and anthers that are shedding pollen. Hold this flower by its stem and shake pollen directly from the stamens on to the ends of the pistils to be pollinated. Tag each flower cluster, rebag, and leave for about 5 days, or until it is certain that fertilization has been accomplished. Then remove the bags, allow the fruits to become fully ripe, and collect the seeds.

Note whether the fruits that come from the cross-pollinated flowers on the original parents are like the other fruits on the plant in color, size, and shape. If, for example, pollen of a yellow-fruited parent is used on pistils of a red-fruited parent, are the fruits red or yellow? How does this compare with crosses of black corn on white?

Grow first-generation hybrid plants from these seeds and self-pollinate some of these for seed for a second hybrid generation. Are the fruits of the first hybrid generation alike as to shape, color, and size? Which parent do they resemble?

Grow a number of the second-generation hybrid plants. Are the fruits of the various plants similar or very different in color, size, and shape? How many are like the immediate parent (first hybrid generation)? Do any resemble the grandparents? Are any of the fruits new in respect to color? to size? to shape? Do any characters of the original parents disappear in the first-generation hybrids and reappear in certain of the second-generation hybrids? Do the plants differ from each other in respect to such characters as size, vigor of growth, shape and color of leaves, amount of fruit produced, and earliness of ripening fruit?

11. *To learn how to cross-breed pumpkins.* Select a pistillate flower that is nearly ready to open. Place a stick firmly in the soil in an upright position beside this flower. Invert a bag over the flower and tie it about the stem of the flower, protecting the flower and stem with a small handful of cotton at the place where the tie is made. Tie the bag to the stick also so that its weight will be supported. Another way to keep insects from entering the flower is to tie the ends of the flower with soft twine or strong yarn. This prevents the flower from opening. As bees are likely

to carry pollen from one male flower to another, it is advisable also to bag or tie unopened male flowers from which the pollen is to be used later in crossing.

In from 24 to 48 hours, depending on development, the staminate flowers whose anthers are open and shedding pollen may be picked. Remove the bags from the pistillate flowers to be crossed, and dust the expanded stigmas with some of this pollen. Then rebag and leave for a period of 4 or 5 days. Tag or otherwise mark the cross-pollinated flowers and allow the fruits to mature.

Grow the first and second hybrid generations, and study the fruits which are produced.

CHAPTER ELEVEN

THE TIME FOR PLANTING

> Planting time! Time to get a spade and tear up the turf somewhere: to clear a space and stir the soil and set in it the roots of some lusty plant-foundlings, in hopes of seeing what they will do when summer comes.
>
> JAMES G. NEEDHAM

RADISHES are planted as soon as the soil can be worked in spring. Lima beans are not put into the ground until at least a month later. The seeds of these crops are planted directly in the garden, but cabbages and tomatoes are grown from plants started indoors or under glass and later transplanted to the open ground.

These different practices are followed because through long experience gardeners have learned that plants differ in their temperature needs and in their growing periods. Some kinds of seeds germinate in cool soil. Others rot unless the soil is warm. Some plants grow best in cool weather. Some thrive only when the heat of summer comes. Some crops grow quickly. Others develop slowly, and it is necessary to start the seedlings early to permit them to mature before the heat of summer or the frosts of autumn check their growth.

The right time for planting a garden crop depends, therefore, not only on the climate and weather of the locality, but also on the heat and light needs of the crop and the length of its growing period. It is well for the gardener first to understand the temperature requirements of the various garden crops, and how long it takes each one to mature. Then he can with profit study the climate of his region. In this way he can find out much that will prove of value in determining the right plant-

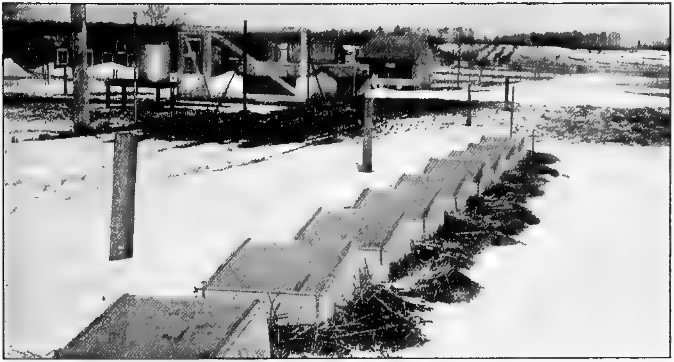

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FIG. 83. A group of home-made plant forcers. One is placed over each plant or hill of plants. It has a frame of wood and a glass top. Each plant forcer is thus a miniature greenhouse or cold frame that can be removed as soon as warm weather arrives. In the illustration the forcers are being used on rhubarb.

ing dates for the vegetables he wishes to grow in his own garden.

TEMPERATURE REQUIREMENTS AND GROWING PERIODS OF DIFFERENT GARDEN CROPS

Garden crops may be divided into *cool-season* and *warm-season crops*. The seeds of cool-season crops germinate in the cool soil of early spring, and their seedlings are not much—if at all—injured by moderate frosts. The growing plants of this class thrive during cool weather, and most of them mature during the cool weather of either spring or fall. In the more southern states many of these crops are "fall and winter" crops, growing and maturing from September to May.

On the other hand, the seeds of many warm-season crops rot in cool soil; the seedlings are injured by cool weather and are usually killed by frost. The plants grow very slowly, except in hot weather, and they are killed by the first autumn frosts. The more quickly maturing of these crops are grown from seed planted in the garden; but in the northern part of the United States the season is too short to allow those with a long growing period to be raised entirely outdoors. The seedlings of such crops are, therefore, started indoors or under glass, and when the soil and air became warm, the plants are transferred to the open ground. In the more southern states the warm-season crops yield harvests from May to October.

Quick-growing cool-season crops. Leaf lettuce, spring radishes, spinach, turnips, and peas are short-period cool-season crops. The seeds are planted in the garden as soon as the soil can be worked in the spring, and the crops mature before hot weather arrives. Onions from sets also are grown in this way. As the seedlings endure frost, first plantings of these crops can be made *from ten days to two weeks before the latest killing frost* of the locality.

Crops of these vegetables may be grown in the autumn also, by planting them late in summer. The varieties that are best for autumn are often different from those that are best for spring planting. During late summer the conditions are rather unfavorable to the seedlings, and properly starting the autumn crops requires more skill than does the spring planting. Success with such crops depends in large measure on careful nurture of the young seedlings.

Forced cool-season crops. Many varieties of head lettuce, pe-tsai, and spring varieties of cabbage, kohl-rabi, cauliflower, and celery mature properly only in cool weather. But they require so long a period for growth that if seed is sown in the open garden, hot weather arrives before the crop is grown. The gardener meets this condition by starting seedlings indoors or in cold frames or hotbeds so that he may have sturdy seedlings 5 or 6 weeks old ready for transplanting into the garden about the date of the latest frosts, or if especially "hardened," even before that time.

All these crops will thrive in localities where the summers are cool, and in such places crops can often be grown during summer. Local conditions of soil and climate may also favor cool-season crops. A clay soil is often a "cool soil." A soil poorly drained in spring may be cool and well supplied with water in summer. A northern slope sometimes gives a good location for cool-season crops.

The late crops of these vegetables are usually grown from varieties especially suited to autumn conditions. But these usually require a longer period of cool weather than is available in autumn, at least in the northern states, where killing frosts may occur early in September.

In the North the autumn crops of these vegetables are most successfully grown as follows:

The seed is sown in outdoor seed beds or in cold frames in mid spring, after the cold frames have been emptied of the plants grown for early plantings. Here they can be well supplied with water and given the partial shade that is necessary. The plants are then transplanted to

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FIG. 84. Cabbage seedlings, photographed just after a spring snowstorm. The cabbage is typical of a group of hardy plants that may be forced indoors and transplanted to the garden early in the season. In the South these hardy plants grow outdoors all winter.

the garden in time for them to become established before the hot weather of summer arrives. The plants grow slowly during the summer, but make rapid growth when the cool weather of early autumn approaches. Celery and cabbage will stand considerable hot weather if abundantly supplied with water.

In the more southern of the planting zones and in a considerable portion of the Pacific coast region, the mild winter weather makes it possible to grow cool-season vegetables as fall and winter crops.

The principal vegetables that can be thus grown are: cabbages, cauliflowers, lettuce, onions, garlic, leeks, peas, radishes, turnips, rutabagas, mustard, spinach, beets, and carrots. The perennial onions and asparagus are of course grown over winter here quite as in the colder zones.

South of a line drawn through northern Alabama, and turning farther north along the Atlantic coast, freezing temperatures occur only during December and January. In this region such vegetables as turnips, rutabagas, and cabbages mature in autumn from seed sown in August and September. Seed of hardy plants like radishes and smooth peas is sown in the open in December, the seed lying dormant in the ground, or the seedlings growing slowly during the period when frosts occur and then developing rapidly in early spring. In the sections with cooler winters, as in the North, the seed is sown as early in spring as it is possible to work the soil.

Throughout the South, especially where freezing temperatures occur during winter, cold frames are valuable for rearing seedlings of such cool-season crops as cabbages, lettuce, onions from seed, and beets. Seeds are sown in October and November directly in the soil within cold frames. Later, in January or February (according to the locality and the vegetable grown), the seedlings thus grown are planted in the garden and produce crops in March and April. Inexperienced gardeners in southern states often make their plantings of cool-season vegetables in March and April, which is the season when these crops should be ready for the table.

Cool-season crops that endure summer heat and light. Vegetables belonging to a second group of cool-season crops have longer growth periods and demand cool weather during their early life, but they continue to thrive or even mature during the hot weather. Beets, Swiss chard, carrots, parsnips, salsify, onions from seed, New Zealand spinach, kale, collard, and Irish potatoes are of this class.

Early varieties of some of these vegetables mature during summer, while other varieties mature later. Swiss chard and New Zealand spinach continue to yield leaves for use as greens throughout the summer. In general, the seeds for these crops may be planted about the dates of the *last killing frost* in spring. The very early varieties of beets, onions, carrots, and Irish potatoes may be planted somewhat earlier.

Perennial vegetables maturing crops in cool weather. The standard garden crops of this class are rhubarb, asparagus, and certain types of perennial onions whose edible parts are used for food only during the cool weather of early spring. These plants continue to live and grow throughout the growing season, and they are left in the ground over winter.

Warm-season crops of short growing periods. Many warm-season crops grow quickly enough to mature from seed planted directly in the garden. Of these crops, sweet corn and snap beans may be sown about the date of the latest killing frost. Okra, cucumbers, melons, squashes, and lima beans are planted about two or three weeks later, or after the soil is thoroughly warmed.

The gardener is often anxious to plant these crops early, but such plantings may be injured by cool weather or even "nipped" by late frosts. Hence it is a good plan to make successive plantings. If the first plantings are killed, the space can be given to some other crop. Planting both early and late varieties of these vegetables is advisable. Extra early crops can be secured by transplanting seedlings raised in cold frames or hotbeds, provided they are grown in berry boxes or dirt bands so that they can be set in the ground without injury to the root system (page 190).

Warm-season crops of long growing periods. These are slow-growing vegetables, and in many of our northern states, if seeds are sown in the ground, the plants do not mature crops before the autumn frosts. The vegetables of this group, which should be grown from forced plants, are peppers, tomatoes, eggplants, and sweet potatoes. To grow good plants, suitable for transplanting, requires from 8 to 10 weeks, except the sweet potato, which requires only about 5 weeks. Transplanting to the field is done after all danger of frost is past.

Spring and summer crops in the South. The planting of warm-season vegetables in the South is regulated according to temperature quite as in the North, except that the planting is done at an earlier calendar date and the growing season is longer. Some of the warm-season vegetables like bush beans do not thrive during the Southern summer, and should begin to mature early. The pole beans, however, do well during the summer. *Kentucky Wonder* and *Southern Prolific* are good summer varieties.

When seeds of the long-period warm-season vegetables (okra, peppers, and especially tomatoes) are sown in cool soil, even in the South, they usually fail to germinate; and if one waits until the ground is warm enough to plant out of doors before sowing such seed, the crop matures late. The early crops of these vegetables are secured by growing the plants under protection in hot-

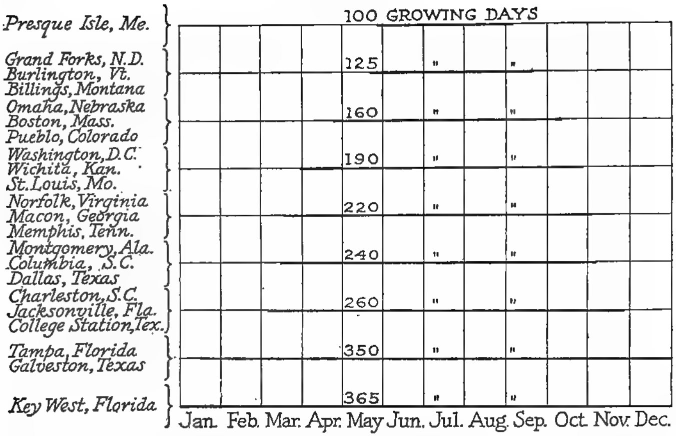


FIG. 85. Chart showing average length of growing season and when the season begins and ends in various localities in the United States. Such a chart for a locality, together with a table of planting dates for different vegetables (pages 348 and 349) are a great aid to the gardener in deciding what crops to grow and when to plant them.

beds and cold frames and transplanting to the garden when danger of frost is over. This may be in February or later, according to the locality.

CLIMATE AND WEATHER

Except in the more southern parts of the United States the actual work of getting the soil ready for planting can be done only when the ground has thawed and dried out after the winter's freezing. As spring advances, the heat received from the sun during the day remains in the earth longer at night, and finally the soil is warm enough throughout the night to serve as the home of the roots of young plants. About this time, and seldom before, the soil becomes dry enough for spading.

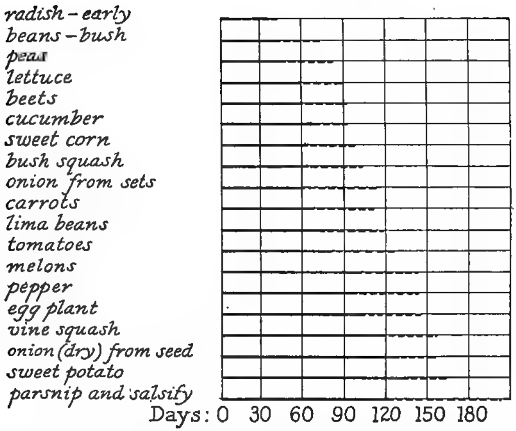


FIG. 86. Chart showing growing period of some common garden crops. The solid line shows the shortest period in which early varieties of the crop can be grown. The dotted line shows the additional time required to bring later varieties into condition for use.

It is usually safe to begin planting the crops that stand cool weather as soon as the soil is in condition to be worked. In many parts of the southern states planting may begin in January or February; in the more northern states the same crops cannot be planted until April or later.

The growing season. The actual growing season of most vegetables extends from the date of the last killing frost in the spring to the first killing frost in the autumn. In the extreme southern part of the mainland of Florida only half the winters bring killing frosts. As far north as Tallahassee, Florida, and Austin, Texas, and also in a narrow strip along the coast of California as far north as San Francisco, the length of the growing season is 9 months or longer. In the extreme northern part of the

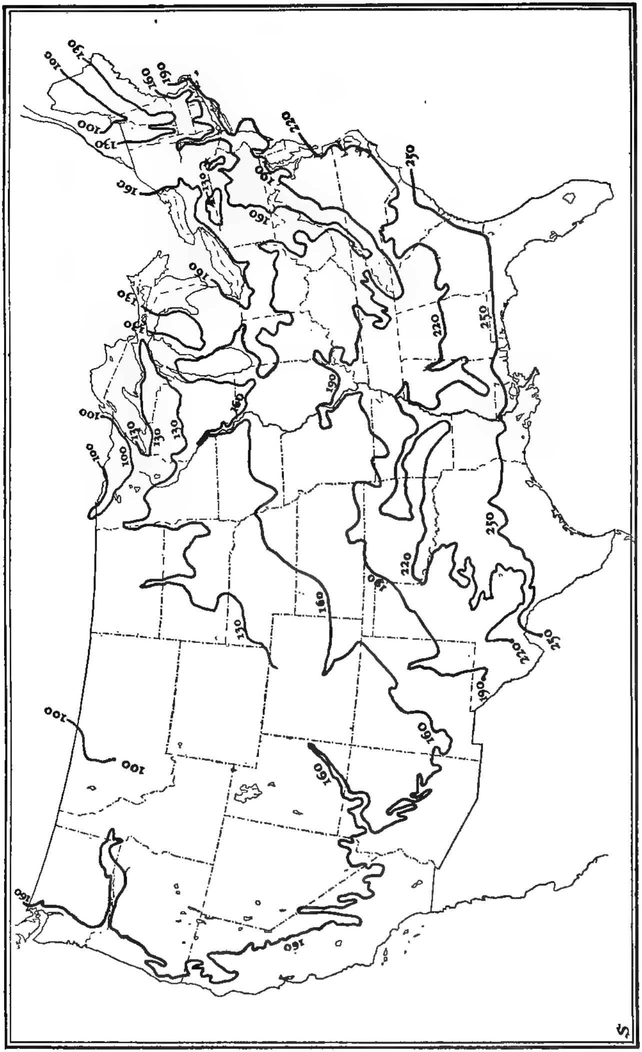


FIG. 87. Map showing number of days in growing season in various parts of the United States.

United States it is less than 4 months. Over a considerable area of the Rocky Mountain region and westward, the growing season for garden plants is not more than 90 days.

Planting zones. Although certain cool-season crops can be planted in spring before the last frost, warm-season crops should not be planted until after frost. It is therefore very convenient, in planning for the spring planting of both seeds and young seedlings, to know about when the latest killing frost may be expected. One cannot tell in advance exactly on what calendar date this will occur, as it varies from year to year. But the beginner in gardening will be helped very much by the maps, prepared by the United States Department of Agriculture, which show the planting zones, based on the occurrence of frost.

In making these maps, lines are drawn through the points where the average date of the last killing frost in the spring occurs on the 1st and the 15th of each month. Thus the line for killing frost in midwinter crosses central Florida and the extreme southern part of Louisiana. In a narrow belt below this line killing frosts are likely to occur each year, and below that they are likely to occur only once in several years. Killing frosts usually occur at points on or about this line about February 15.

Two weeks later (March 1) localities much farther north experience their latest frost. Each two weeks sees the frost line move farther north (as shown on the map, Fig. 88) until about June 1, when the last killing frosts in the United States occur in the extreme northern parts of North Dakota and Minnesota.

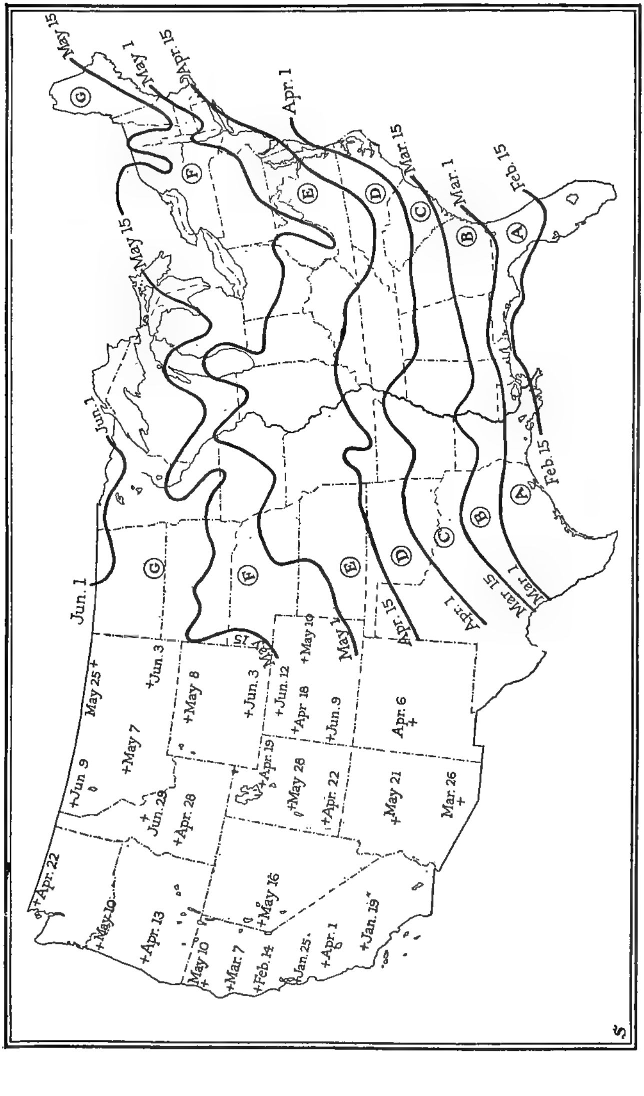


FIG. 88. Map showing planting zones according to the average dates of the last spring frosts. The lines are drawn through the points where the last killing frosts occur on the 1st and 15th of each month.

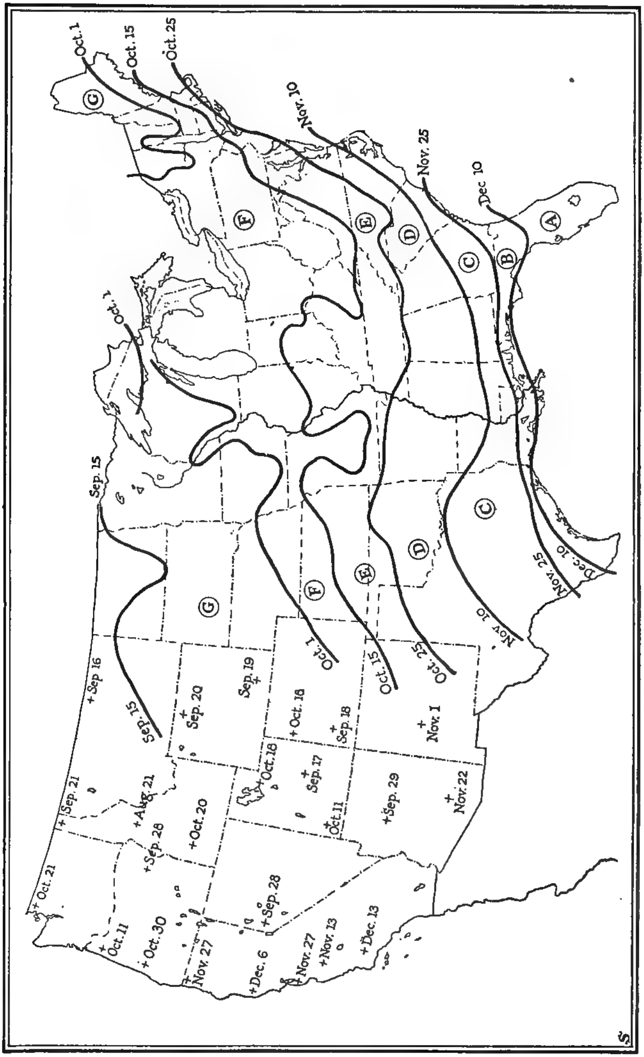


Fig. 89. Map showing average dates of first killing autumn frosts. In the center of a zone frost may be expected at a date about midway between the frost dates on its northern and southern margins.

The eight lines drawn mark off into zones that part of the United States east of the Rocky Mountains. In each of these zones the range of planting dates in spring averages about the same. The earliest dates for planting the various vegetables in these zones are given in the table on pages 348 and 349. There are, of course, local conditions, such as elevation, drainage, and the slope of the land, not indicated on a map of this kind, which change somewhat the planting dates as given. Each gardener must find out for himself the more exact planting dates for his own locality and his own garden.

The western part of the United States is broken by mountains and streams, which cause so much irregularity in the frost dates that it is not possible to mark out this area into definite planting zones.

The killing frosts of autumn. The first severe frost in autumn kills most garden plants. Tomatoes, corn, beans, peppers, and eggplants are killed or badly injured; beets, carrots, cabbages, lettuce, turnips, pe-tsai, celery, endive, and kale are not severely injured and may be left in the garden until just before the ground is frozen. Parsnips and salsify can be left in the ground over winter, but even these more hardy plants practically cease growth with the coming of severe frosts.

In planning for late or autumn crops, and especially for the succession crops, the gardener should know (1) how long a period is required by the particular crop to mature, and (2) when the first killing frosts are to be expected. This is especially important in the northern states, where frosts come earliest.

Fig. 90. Low-growing garden crops may be protected from an early autumn frost by the method shown above. Peach baskets or light boxes are inverted at intervals along the row, and boards laid on them. Then burlap bags, old mattings or carpets, or any other coverings are spread over the boards. Sometimes the season for vegetables like beans, tomatoes, peppers, and egg-plant can be prolonged for weeks by protecting the plants on the one night of the frost.

The average dates of first frosts in autumn are shown on the map on page 159. In making this map effort was made to leave the zones the same as in Fig. 88, but the boundary lines do not coincide, because different localities having the latest killing spring frosts at the same time do not always have the first killing frosts of autumn at the same time. The map, however, aids one in judging the probable date when the first autumn frost will kill garden crops.

A chart for latest plantings. Knowing the date when killing frosts may be expected and the number of days required for a vegetable to mature, one can decide when the latest plantings should be made, or whether the entire growing season is too short for a crop to reach maturity. This information has been arranged in a form useful for ready reference in the chart on page 350.

Practical use of these maps and charts. Judging the probable date of the latest frost in spring helps the gardener to determine when to prepare hotbeds and cold frames and when to sow seeds for plants that are to be transplanted to the garden.

Knowing the temperature needs of the various crops and the probable or average date of latest frost helps the gardener to judge when to plant seeds or transplant seedlings in the open ground during spring.

Knowing also the probable date of the first frosts in autumn and the length of time the crops require for maturity will enable the gardener to plant for late or follow crops at the best time.

Local records of frost dates. The gardener should keep an accurate record of the frost dates — the earliest in autumn and the latest in spring — from year to year. Such a record can easily be kept at the public school of the locality in connection with garden work, or with studies of physical geography or elementary science.

Reliable local records give an opportunity to correct the general maps, which cannot show local conditions.

The longer such records are kept, the more valuable they become for judging the average or probable dates of frost. In connection with these records, it will be helpful to keep notes regarding varieties planted, planting dates, date when first of crop is gathered, quantity and quality of yield, and special treatment given in respect to culture or fertilizers. Such data will help the gardener later, in planning for the next year's garden, in selecting varieties best suited to local conditions, in planting these varieties at the most suitable time, and in caring for them so that they will produce the best crops.

Questions

On what two factors does the right planting time for a garden crop depend? Into what two great classes may crops be divided according to their heat requirements? Why are some cool-season crops grown from seed planted directly in the garden and others by the transplanting method? Name some crops grown in each of these ways. What conditions other than a cool climate may favor the growth of cool-season crops? What perennial garden vegetables mature in the spring?

What crops mature best in warm weather? Which of these are grown directly from seed planted in the garden? Which have to be started under glass?

What is meant by the "growing season"? What is meant by a "planting zone"? In what planting zone do you live? What crops listed in the chart on page 155 can reach full maturity in your garden? In your region, when should winter cabbage, requiring 120 days for maturity, be planted? curled endive, requiring 90 days for maturity? How can peppers and eggplants be grown successfully in a locality having an outdoor growing period of 90 days? Why can parsnip and salsify be grown from seed in localities where the growing season is 100 days or less? How will this crop compare with that growing where there are 125 days in the actual growing season?

Things to Do and Observe

1. *To make a table of planting dates.* Make your own locality tables of earliest and latest planting dates, similar to those on pages 348–350. Visit successful gardeners and see if your table agrees with their judgment as to best planting dates. Do people usually make mistakes by planting the various garden crops too early or too late?

Record the dates of the last killing frost in spring and the first killing frost in autumn, as they occur in your locality. Compare these with the averages on your map. Write to the United States Weather Bureau and get the record of frost dates at the observation station nearest your home.

2. *To learn to determine planting time by the advancement of vegetation.* The Indians had no Weather Bureau records, but they judged of the proper time for planting by the advancement of the vegetation. "When the oak leaves are as big as a mouse's ear, then plant corn," is the rule they gave the New England settlers. Observe the early flowers and shrubs that are in bloom and the buds and leaves on different kinds of trees as each vegetable is planted. A record of these observations will be most helpful in judging the variation in planting dates required by the differences in seasons.

CHAPTER TWELVE

HOW TO GROW PLANTS FROM SEEDS

The sturdy seedling with arched body comes
Shouldering its way and shedding the earth crumbs.

ROBERT FROST

WHEN a live seed is planted under proper conditions, it *germinates*. The tiny plant within it breaks out of the seed coat, thrusts its roots out into the soil, and pushes its stem and leaves up toward the light and air.

To awaken the young plant in the seed to active growth certain conditions must be supplied. And the time when the little plant is leaving its old home in the seed and establishing itself under new conditions is the most critical period of its whole life. To get his crops properly started, therefore, the gardener must understand when and how to plant his seed and how to care for the seedlings during their early life.

What seeds need for germination. When seeds are planted, they lie with the soil particles all about them. Everything they obtain comes through the soil, and if they are to germinate and grow, the soil must be in condition to supply their needs.

First *water* soaks into the seed and gives the living cells of the embryo the moisture required for growth. Water also softens and weakens the seed coat, which permits the growing embryo to break out more easily. Without water, seeds will not germinate, for, as we know, dry seeds may be kept for years. And if the supply of moisture fails after germination is started, the little plant dies. When the embryo has once begun growth, it is not able to stop and become dormant again as it was in the seed. A continual supply of water is therefore necessary.

With the very beginning of growth, the embryo needs

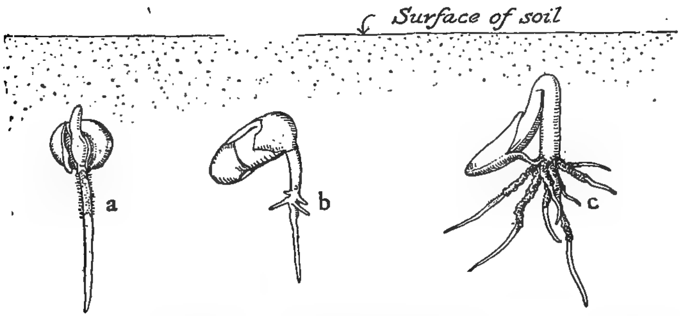


FIG. 91. The germination of corn, bean, and squash. In the corn (*a*) the little plant pushes out both stem and root and grows upward, leaving the seed in the ground. In the bean (*b*) the root grows out and turns downward, and then the part just above the root grows into an arch and pushes upward, dragging the seed with it. After this the seed coat is burst open and the first two seedling leaves (cotyledons) are freed. In the squash (*c*) the seed coat is caught against a small "peg" just above the root and held, while growth forces the cotyledons upward and pulls them out of the old coat.

an additional and constant supply of *oxygen* for respiration. This comes from the air that is held in the spaces in the soil. But if water completely fills the spaces between the particles of soil in which seeds are planted, the seeds will decay because of lack of air, just as they do if left in a dish with water covering them. Hence seeds germinate best when the soil about them is moist with capillary water but has no free water in it.

A certain amount of *warmth* is necessary to start growth in a seed. The amount required is greater for seeds of warm-season vegetables than for those of cool-season plants. In fact, the best temperatures for germinating the seeds of various garden crops differ very widely.

Seeds of a cool-season crop, like mustard and cabbage, will often germinate well at temperatures as low as 32° to 38° F.; but the best temperature for their germination is about 60° to 80°. On the other hand, seed of melons will usually not germinate at all if the temperature is below 55°; the best temperature for their germination is somewhere between 90° and 100°.

Germination is most rapid at the more favorable temperatures. Thus muskmelons require 12 days to germinate with a soil temperature of 60°, but will germinate in 48 hours with a soil temperature of 88°. This shows clearly why nothing is to be gained by planting seeds of the warm-season crops while the soil is yet cold. If the soil temperature is too low, germination will not take place at all and the seed may decay.

It is an interesting fact that many seeds will germinate well at somewhat lower temperatures than is most favorable for the later growth and development of the plant. The garden mustard germinates at only a little above the freezing point; but by the time the seedlings have become established, spring is more advanced, the air and the soil are warmer, and the temperatures and hours of sunlight are more nearly those required for vigorous growth. The natural conditions prevailing in spring and in summer are hence quite normal for the changing needs of the plant.

The differences between the best temperatures for germination and for growth are least for warm-season crops. The seeds of melons germinate best at 90°, which is about the temperature most favorable for vigorous growth of the plant.

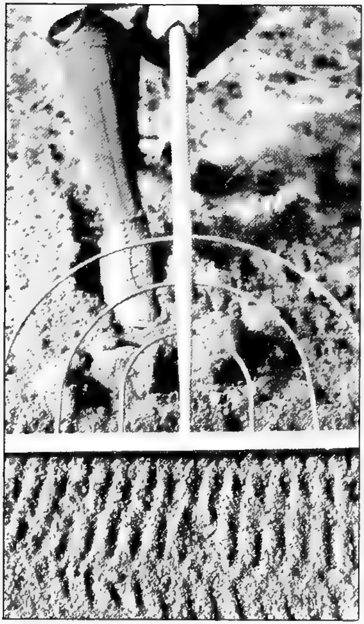
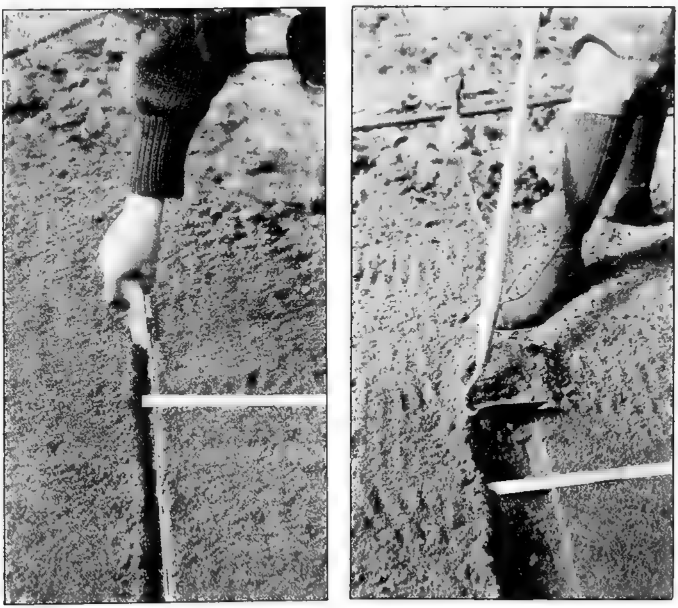


Fig. 92. Making ready for planting. The surface of the soil should be raked fine before marking out the rows.

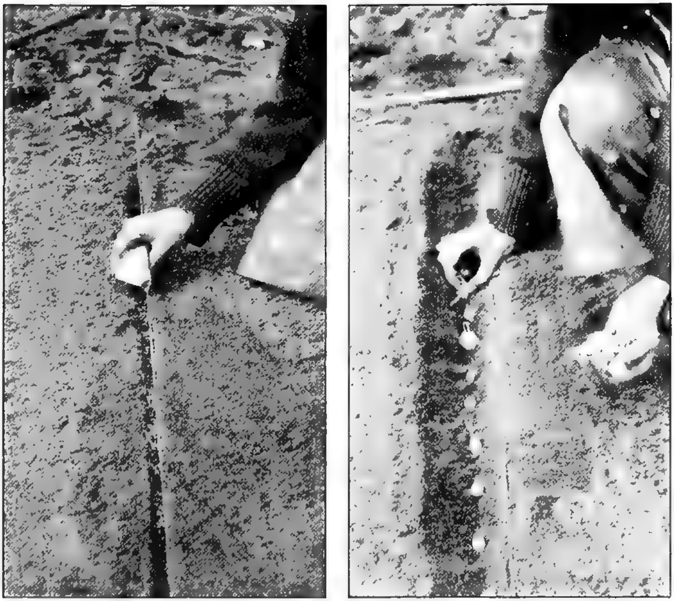
Preparing the ground for planting. Before planting, the ground (which has already been well spaded or plowed and perhaps raked) should be raked to break up or remove lumps and to secure a surface layer of fine soil. It is usually best to plant a well-drained and well-tilled garden soon after spading, before the top layer becomes dried out. But if a garden soil is poorly drained and cold, it may be spaded and left without raking, both in autumn and in spring. For a time this will make the soil cold because of the evaporation of water from it; but after the free water is gone, it will quickly become warm. Before planting, however, the surface should be well raked. The lumps will break up more easily and a better supply of moisture will be held in the ground if this is done as soon after a rain as the soil will work properly. The surface mulch will check evaporation and help to keep the soil both warm and moist.

How to lay out and plant a row of seed. The seeds of most garden vegetables are planted in shallow trenches which make rows across the garden. In order to get the row straight it is a good plan to make the furrow along a tightly stretched line.

First drive a stake firmly at each end of a row. Then stretch the line between the stakes so that it lies on the ground. To make sure that the line is straight, lift it near the center to a height of a few inches and allow it to



FIGS. 93 and 94. Laying out the rows. The furrow at the left is for fine seeds. The furrow at the right is for coarse seeds or onion sets.

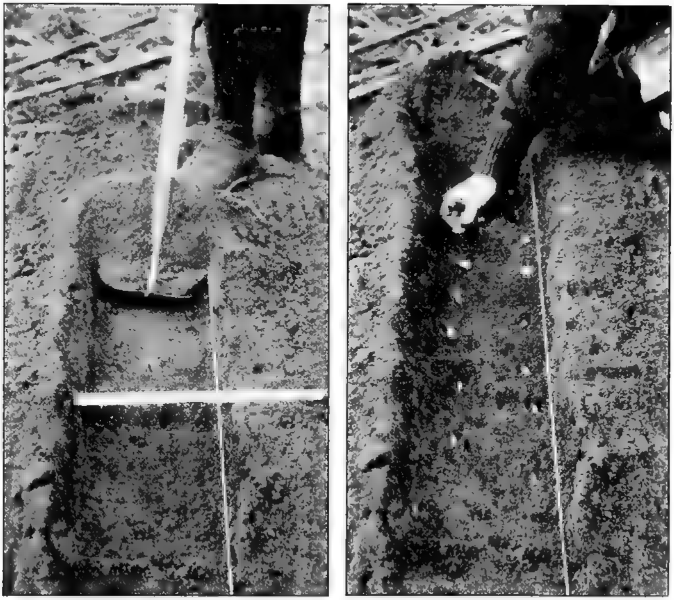


FIGS. 95 and 96. Planting. Only an expert can sow fine seeds successfully from the packet as this person is doing. It is better for the beginner to put the seed in a cup and take out a few at a time between his finger and thumb. Note the even spacing of the onion sets.

snap down. It will then be straight if it has been stretched taut.

Then make a furrow by drawing the edge of a square hoe along against the line and pulling the dirt to the side away from the line. In this way it is easy to make quickly a straight furrow of a depth suited to the needs of the seed to be planted.

In planting small seeds like those of radishes, lettuce, onions, carrots, or beets, the seeds should first be poured from the packet into a shallow dish or a saucer. Then a



FIGS. 97 and 98. Making and planting a double-row furrow. This method is often practiced on very rich soils, particularly when space is limited. One advantage of the double row is that it gives increased yields for a given amount of space; another is that the plants in the double row support one another better than in the single row.

few seeds may be taken at a time between the forefinger and the thumb and scattered at proper distances along the bottom of the trench. If even an experienced gardener tries to sow directly from the packet he usually spills the seed sooner or later.

Spacing the rows. Proper spacing of rows is necessary to give the plants the room which they need for maturing. The best spacing suitable to the particular crops to be planted, to the sort of cultivation employed, and to other conditions of the garden should be determined in advance of planting at the time when the garden plan is made (see Chapter 8). Suggestions as to the proper spacing of rows and of plants in the row will be given in the directions for the culture of the various crops.

Depth of planting. If seeds are planted too deep, they may die and rot because they are too wet and too cold and do not have enough air. If they are planted too shallow, there is danger that they will dry out or be washed out by heavy rains.

Different kinds of seeds have different germination needs and must be planted at different depths. Corn, peas, and beans should be planted 2 or 3 inches deep; seeds of beets, cucumbers, squashes, and melons about 1 inch deep; and small seeds like those of carrots, radishes, lettuce, and parsnips only about $\frac{1}{2}$ inch. The seedlings from the smaller seeds are not so strong as those of larger seeds and hence are not able to push their stems and first leaves up through so much soil. But one cannot follow exactly any "rule of thumb" in planting. Under the discussion of the various crops later, suggestions as to planting will be given. However, it is well to remember that, generally speaking, *seeds should be planted deeper in a loose, warm soil than in a cold, heavy soil; and later in the season when the ground is warm they should be planted somewhat deeper than in early spring.* Peas might well be planted 3 inches deep in light, sandy soil, but not more than 1 inch deep in heavy soils.

Covering seeds. After sowing, the seeds should be covered with soil, and usually this soil should be firmed about the seeds. Firming brings the soil particles close against the seeds, so that the soil water can pass into them and the first roots of the little plants can readily come into contact with the soil. It also increases the amount of water in a given volume of the soil by pressing the soil particles closer together, thus reducing the air space.

FIG. 99. Covering the seeds. Fine soil should be drawn carefully and evenly over the row.

A sandy soil or a dry, loose soil should be firmed by walking slowly along the row of planted and covered seeds, treading the soil with the ball of the foot but not with the heel. A loam should be firmed in the same way when it is dry. If a soil is moist, light strokes with the back of the hoe will press it down sufficiently under most circumstances. When very dry, a clay soil may thus be firmed with the hoe; but firming down a moist clay soil in any manner will make it too compact.

After the firming, fine dust from between the rows should be lightly raked over the planted row. This leaves a thin layer of dust mulch over the compacted or firmed soil.

FIG. 100. Watering the bottom of the furrow before planting the seed. In dry weather this is often done where the soil is sandy or loose, but with clay soils care must be used to prevent puddling.

Proper firming of the soil is especially important in summer planting. Without it the seeds may lie in the loose, dry soil and fail to germinate. Or the little seedlings may die after germination starts, because the tiny rootlets may find their way into air pockets among the lumps of loose soil instead of getting into contact with soil particles that will furnish the water that the plants must have.

Watering at planting time. Watering immediately after planting seeds is not advisable. It compacts the surface layer of soil; then, when this dries, it cracks and gives out moisture very rapidly. If the ground is dry, soak the area to be planted some 24 hours before planting. Then, after planting, rake up a surface mulch. To hold the moisture in the soil it is often advisable to shade carrots and Chinese cabbage that are planted in hot weather until the young plants begin to appear.

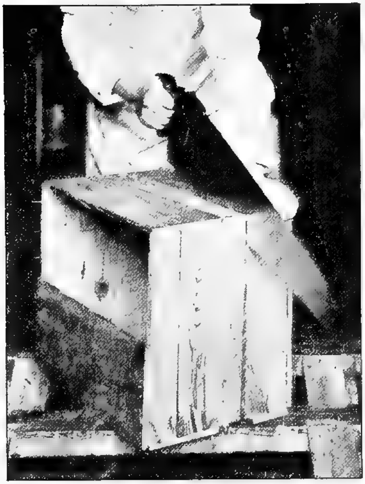
REARING SEEDLINGS FOR TRANSPLANTING

Many vegetables can be brought to maturity earlier by starting the plants indoors. The seeds are planted in boxes or flats or even in cans that are filled with earth, and the growing seedlings are kept in warm rooms or in hotbeds. Literally, these boxes are small gardens in which crops are grown until it is warm enough to plant them out of doors. As soon as the weather permits, the seedlings are transplanted to the garden; and because they are already of considerable size and have roots and leaves developed, they mature sooner than the same crops would if the seed were sown in the garden.

In this way cool-season crops like cabbage, pe-tsai, and lettuce may be brought to maturity before the hot weather of summer arrives. Long-period warm-season crops like tomatoes, eggplants, peppers, and sweet potatoes can thus be had earlier in the season and may also be matured where the outdoor season is shorter than the plant requires for full growth.

One can often buy plants, ready for transplanting, of such crops as cabbages, tomatoes, eggplants, and peppers; but often these plants are poorly grown and the name of the variety is uncertain. The gardener will find it to be an advantage if he can grow his own seedlings for transplanting, unless he can buy good plants from a reliable source.

Making flats. Flats are shallow boxes or trays, about 3 inches in depth, in which seedlings are grown. They are most easily made by sawing off the bottom part of boxes of suitable sizes. Or they can be made from



States Relations Service

FIG. 101. The easiest way to make a flat.

boards cut to the right form and nailed together. A few holes, $\frac{1}{2}$ inch in diameter, should be bored in the bottom to allow good drainage.

It is well to make flats of such sizes that they will fit into available hotbeds and cold frames without loss of space. Six flats, 20×14 inches, conveniently fill a single sash 6×3 feet in area. Smaller flats, however, are easier for children to handle.

The seed may be germinated in small earthen pans or in small boxes (cigar boxes will do), filled with ordinary garden loam mixed with sand, and the seedlings "picked" out, after germination, into the larger flats containing richer soil.

Soil for the flats. A good soil for the *seed* flat is made by mixing sand with the ordinary garden loam. If a rich soil containing decaying manure and compost is used, it is likely to force the young plants too rapidly and lead to development of "damping-off" diseases.

For filling flats to which seedlings are to be transplanted, a good soil can be made from equal parts of sand, good garden soil, and well-rotted manure or compost. Sift the sand and soil through a fine sieve (galvanized wire screening of $\frac{1}{4}$-inch mesh can be used in making the soil sieve), but put the manure through a still coarser one ($\frac{1}{2}$-inch mesh). The sieves can easily be made by nailing screening to wooden frames of convenient size. Thoroughly mix the sifted materials, and if dry, sprinkle with water until moist.

Such a soil is high in fertility, and it will remain loose for some time under repeated waterings. If sand is lacking, the drainage is likely to be poor; if there is too much manure, the plants are likely to grow too rapidly and become "soft" and subject to "damping-off" diseases.

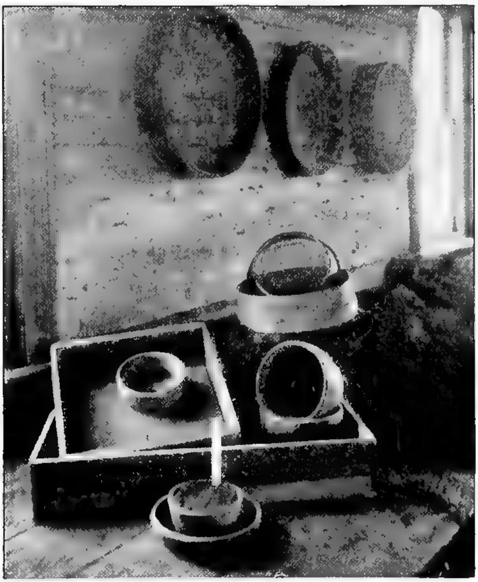


FIG. 102. A gardener's equipment for preparing the soil for flats and pots. The earth is piled upon the bench in readiness for sifting. The soil sieves have meshes of different sizes.

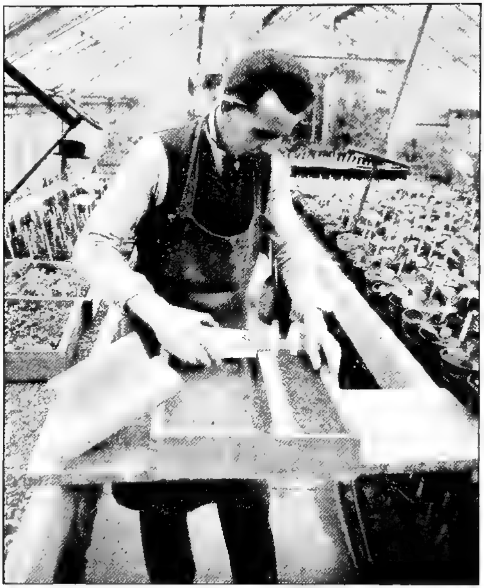


FIG. 103. A professional gardener planting seed in a flat. The flats are conveniently supported on a board laid between the greenhouse benches, the rows are laid out by a wooden strip of proper width, and the soil is firmed with the tool resting against the left side of the flat.

Cover the drainage holes in the bottom of the flat with pieces of coal, small stones, or broken earthenware. Then fill the flat with the prepared soil, level off even with the top, and firm the soil by pressure with a piece of board. The flat is now ready for the planting of the seed or for the work of transplanting.

Planting the seeds in the flat. Seeds may be scattered, or they may be sown in rows in the flat. If they are planted in rows, make furrows about 2 inches apart and about $\frac{1}{4}$ inch deep; this is deep enough for the small seeds of the vegetables usually thus grown. Scatter seeds about $\frac{1}{4}$ to $\frac{1}{2}$ inch apart in the row and cover them by sifting on more soil. If the seeds are scattered broadcast in the flat, $\frac{1}{4}$ inch of soil should be sifted over the seeds after they are sown.

Place labels at the ends of the rows, or if all rows are of one kind, at the middle of one side. Record the name of the variety and the date of the planting on each label.

The first waterings should be made gently with a fine spray. It is a good plan to lay a cloth (a coarse gunny sack will do) over the flat and sprinkle water over it, allowing the water to trickle through into the soil. After the seeds have been planted, the flats are ready to be placed where the seeds and seedlings ill obtain warmth and sunshine. Water must be supplied daily as needed.

Growing seedlings in window boxes. Seedlings of vegetables like cabbages, tomatoes, and peppers can be grown in flats in the home. As a rule, the plants should have all the light a south window will give. Turn the flats from day to day so that all sides may have an opportunity to face the light. Extremes of heat and cold injure the plants; the room should not become too hot by day or too cold at night. If the room approaches freezing temperatures during the night, the flats should be removed from the window to a warmer place. During the night the flats may be covered with newspapers or with a blanket.

An easy way to do this is to set the flats on the seats of two chairs that face each other closely and then place a blanket over the backs so that it reaches to the floor all around. A well-lighted basement in which the furnace is located is often warm enough for growing seedlings.

Since water gives off its heat slowly, watering with lukewarm water at bedtime helps to keep the soil warm at night, provided evaporation is checked. But because of the cooling effect of the evaporation of water, it is well, unless the plants are covered at night, to water in the forenoon so that the top layers of soil are rather dry at night.

The hotbed. A hotbed is simple in its construction and is not necessarily expensive. It consists of a glass-covered frame, which is placed over a bed of decaying manure. The frame and glass keep out the cold air and keep in the warmth; the decaying manure supplies heat; the glass allows the sunlight to enter during the day.

The frame may be made of boards $1\frac{1}{2}$ or 2 inches thick

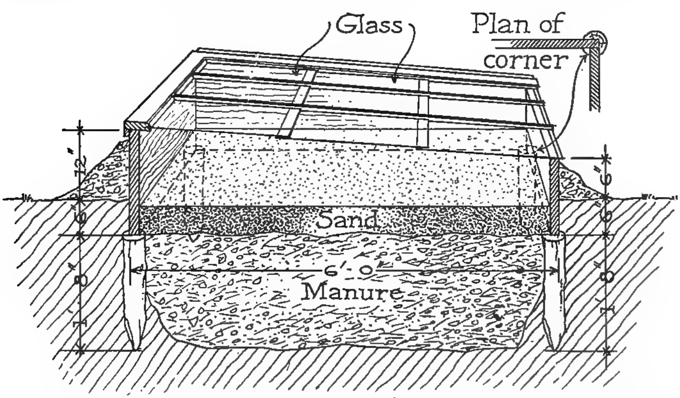


FIG. 104. Diagram showing the details in the construction of a hotbed.

and is usually of the shape shown in the accompanying diagrams. The top is fitted with glass sash, which is

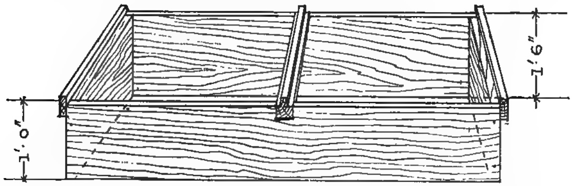


FIG. 105. Diagram showing the completed frame of a hotbed.

given a sloping surface to shed the rain. The standard size for the sash is 3×6 feet; so a frame 6×6 feet will be covered by two sash. A hotbed of this size is large enough to supply plants for the small home garden, but the size and shape of the frame may be made to suit any sash that may be at hand. The sash of the storm windows may be used as a covering, as the hotbed is not started until the most severe weather of winter is past.

The hotbed should be located on a well-drained spot. Its sloping surface should be fully exposed to the south. On the north it should be protected by a fence, a hedge, a wall, or a building. It should be near a supply of water and within the vicinity of a building or basement in which the work of seed sowing and transplanting from flat to flat can be done very easily.

Making the hotbed. To make a *pit hotbed*, dig a pit about 20 inches deep and of the exact size and shape of the frame to be used. Then drive a post at least 6 inches in diameter at each corner, so that all the tops are on a level about 6 inches below the surface of the ground.

FIG. 106. The first step in preparing the hotbed. Throwing in and trampling down the manure.

The frame is then placed in the pit, with the corners resting on these posts, and a nail driven through the frame into the post at each corner. This arrangement holds the frame firmly in place and keeps it from settling.

Next, pack fresh horse manure firmly into the pit to a depth of about 16 inches. The manure should be about two-thirds straw and should not have been exposed to the weather. It is best for use when about 10 days old and after it has been kept in a pile and forked over two or three times. None but horse or mule manure is satisfactory. Place the manure in the pit in thin layers, trample each layer until it is compact, and be sure that the corners are well filled and that the surface is level.

If seedlings are to be grown in flats, from 4 to 6 inches of sand is then placed on the manure. If seeds are to be sown directly in the bed itself (this is not recommended), good garden soil is used instead of sand. This brings the level of the material within the frame up to the level of the ground outside. Above this the front of

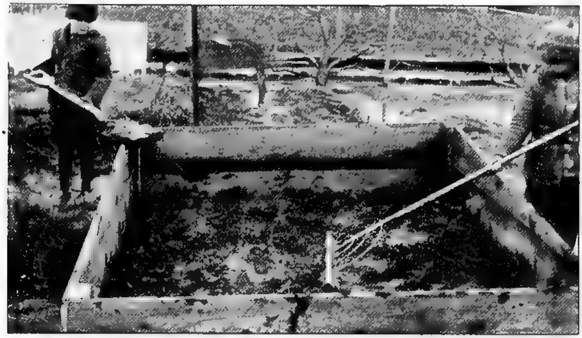


FIG. 107. Adding the soil and raking it smooth.

the frame rises 8 inches and the back 14 inches. Earth or manure should be banked about the frame to its upper edge.

The pit is finally well sprinkled with water and the sash put in place. The decay of the manure gives rather violent heating within a few days, but after about 10 days the temperature lowers; the frame may then be ventilated and flats containing seeds placed within. Under no circumstances should seeds be planted or flats with seeds be placed within the hotbed during the period of violent heating. The temperature may be determined by the use of a hotbed or a dairy thermometer. Thrust the bulb end into the manure. The temperature will often rise to 110° F. or higher; when it drops to 80° or 85°, and not before, it is safe to place seeds in flats within the frame.

Surface hotbeds are made by placing the frame on a bed of manure which is placed upon the surface of the ground. No pit is dug. The frame is constructed as for

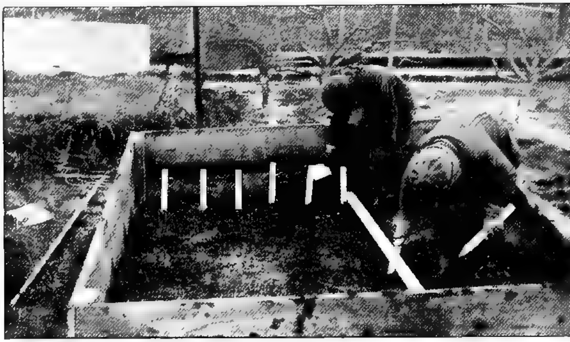


Fig. 108. Planting the seeds and marking the rows. Here the seeds are being planted directly in the soil of the hotbed, but usually it is better to plant them in flats and set the flats in the hotbed.

a pit hotbed. Manure is packed in the frame, and sand added as in the pit hotbed. If kept well banked, the surface hotbed is very satisfactory.

Management of the hotbed. To use a hotbed successfully, the amount of moisture and the temperature within it must be properly regulated. Water should always be applied in a fine spray from a sprinkling can or a hose. The soil in the flats should never become dry, but too much water is to be avoided. On cool, cloudy days very little or even no water is needed. On bright, sunny days the flats should be watered in the early forenoon and the bed ventilated (unless the air outside is very cold) so that the leaves of the plants will become dry before night.

Ventilation also is needed to regulate the temperature. On warm, sunshiny days the hotbeds may become too warm in the middle of the day. To reduce the warmth, raise one edge of the sash on the side *away* from the wind and place under it a block of wood or a brick to hold the sash at the height desired. If the weather suddenly becomes cold or cloudy, the sash should be shut down.

In extremely cold weather, and especially at night, the sash may be covered with straw, blankets, old carpet, or the matting which is made for this use. As spring advances, the sash may be raised higher and for longer periods during the day, until finally they may be removed, to be replaced only on cool nights.

At the time seedlings burst from the soil they may be somewhat "burned" by midday sunshine. This may be prevented by spreading a single sheet of newspaper over them during the middle of the day for a day or two. Freshly transplanted seedlings should thus be shaded. Plants standing in the middle of the frame will receive more light than those at the edge; so it is a good plan to shift and turn the flats from time to time. Usually the growing plants are given all the sunlight that is available.

After it is properly started, only a few minutes are required each day to care for the hotbed; but daily attention and management, according to changing weather, is absolutely necessary for the best results.

Construction and use of a cold frame. A cold frame consists of a frame with a sash or cloth covering. It is usually placed directly on the ground. No artificial heat is supplied as in the hotbed, but the frame affords protection from the cold air of the outside. The covering of sash or cloth helps to retain over night the heat received from the sun during the day.

Cold frames are especially useful for hardening seedlings previously grown in a hotbed. This is done by

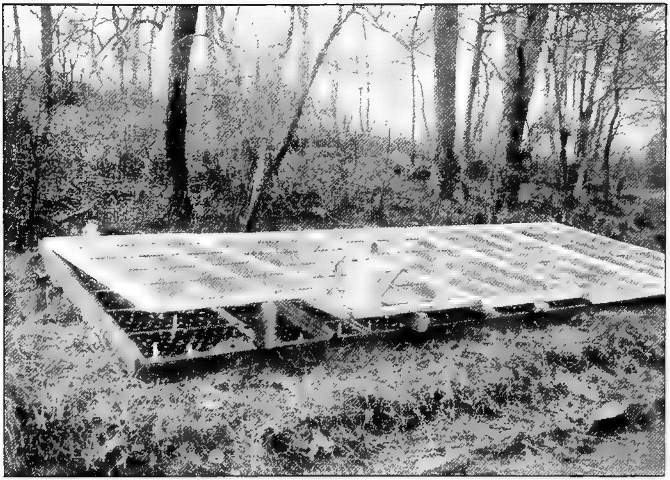


FIG. 109. A cold frame at the New York Botanical Garden. Flats of seedlings are placed in the cold frame for growth and for hardening.

transferring, at the proper time, the flats of seedlings to the cold frame. Seedlings to be transplanted to the garden in late spring or during summer may be grown directly in the soil of the cold frames. The soil should be well tilled and should contain only small amounts of manure. One should never stand or walk directly on the soil in a cold frame, but on a board placed on the surface within the frame.

Transplanting from flats to other flats. It is not best to leave seedlings of cabbages, tomatoes, celery, lettuce, peppers, and eggplants in the flats in which the seed was sown until they are large enough to transplant to the garden. The soil is likely to become compacted, and the seedlings are usually too crowded. It is therefore best to reset the plants once or even twice before they are placed in the garden.

When the seedlings are about 2 inches tall, they may be transplanted into flats which are filled with somewhat richer soil than was used in the seed flats. In this transplanting the best plants can be selected and respaced so that they will have sufficient room for further development. One can thus avoid the common mistake of growing many more seedlings than are actually needed and of leaving them so crowded that none of the plants will be well developed.

For example, if one needs 36 tomato plants for the

FIG. 110. A gardener transplanting seedlings to a second flat. Only the more vigorous seedlings are selected for transplanting.

FIG. 111. A home gardener transplanting her seedlings. They were grown in a small window box and are being transplanted to a flat to give them more room and to cause root development.

garden, a small packet of seed may be planted in a seed pan or a flat 12×12 inches, or in a part of a larger flat. Perhaps 200 seeds will germinate, and the seedlings will be more or less crowded and irregularly spaced. Of these, 50 of the best plants may be selected and replanted in flats so that they stand at least 2 inches apart. In this way enough plants for the garden will be obtained, and the chances are that most of these will be strong and vigorous.

A second advantage in transplanting seedlings several times is that it often stimulates a more vigorous development of the roots. This is especially true of celery. The main taproot, which tends to go straight down, is broken, and side roots branch out which make a much larger and better plant.

For cabbage, kohl-rabi, head lettuce, tomato, pepper, eggplant, and celery the young seedlings should be transplanted from the seed pan to flats when from 1 to 2 inches in height and given plenty of space in the new flat. Transplanting from seed pans to flats, as the plants become larger, requires more room in hotbeds; but by this time the weather will probably be mild enough to allow the use of cold frames or temporary shelters for some of the flats.

Special methods of growing seedlings. The seedlings of bean, corn, pumpkin, squash, cucumber, and okra may also be started in a greenhouse, hotbed, or cold

FIG. 112. Carrying seedlings that have been grown in a cold frame to the garden for transplanting. This picture illustrates the proper way of carrying a flat. Notice that the fingers of the right hand are crooked around the corner of the box. By holding a flat in this way there is no danger of tipping it, or of losing the balance of the box and thus dropping it.

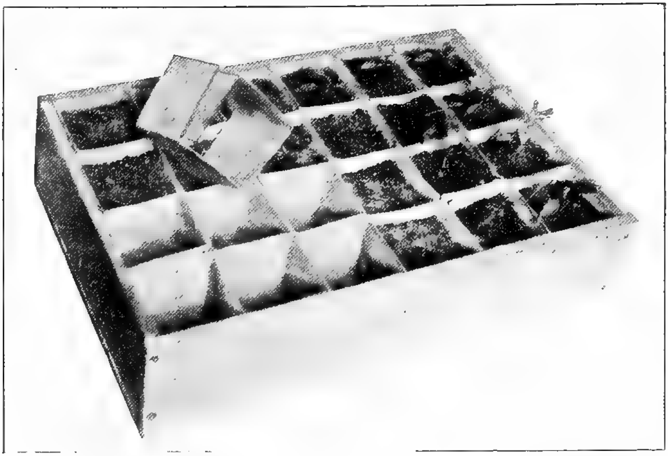


FIG. 113. A flat filled with dirt bands. A dirt band is very easily made; it is merely a strip of cardboard folded to form a square, as shown in this illustration. Plants grown in this manner can be transplanted with almost no disturbance of the roots.

frame. But seedlings of these grow rapidly and have rather coarsely branched roots which make transplanting difficult. They may be handled successfully by growing a few seedlings each in wooden berry boxes, pots, or any containers of small size.

When grown in flats, the plants may be arranged in groups of from three to five and the roots of each group kept separate by bands of cardboard, in what is called the "dirt-band" method. In transplanting to the garden, the mass of soil with the enclosed roots is not allowed to break up. Tomatoes and cabbages can thus be grown with a single plant in each "dirt band" (see Figure 113).

Hardening plants. Plants should never be transplanted to the garden without hardening. The sudden change from the warm air of the hotbed or greenhouse to the open air may so injure the tender plant that its growth will be checked for days. As the warmer weather approaches and the plants that are being grown in flats become larger, they should be exposed to the open air for longer periods each day. Finally, they may be left uncovered, even throughout the night. Shortly before the plants are to be placed in the garden, flats may be left without any other protection except that of near-by buildings which keep off the winds. During the period of hardening, the plants should be rather sparsely watered, but care should be taken to prevent them from becoming wilted; their growth must not be checked in any way.

Transplanting to the garden. Water the flats containing the plants *thoroughly*, at least an hour before the work is to begin. This allows the cells of the plant to become well filled with water, and it causes soil to adhere to the roots. Dig well under the plants, breaking the roots as little as possible. Reset a plant immediately, before it has time to wilt. Make a suitable hole with a trowel, set the plant somewhat deeper than it formerly grew, completely fill in about the roots with fine soil, and gently firm the soil about the roots. Be sure that the soil is carefully filled in so that no "air pockets" are left about the roots. In the school garden or in the home garden there are usually so few plants to be transplanted that one can afford to take time to do the work well. Water the plants by applying small amounts in a fine spray at intervals of a few minutes, so that the water sinks into the soil without any puddling.

FIG. 114. Right and wrong ways to treat a potted seedling before transplanting. The plant at the left was kept well watered and the roots were undisturbed. The transplanting will check its growth only slightly, if at all. The roots of the plant in the center were also undisturbed, but the plant has been given no water for 24 hours. It will probably be set back severely in its growth. The plant at the right was kept watered, but the roots were pulled from the soil and left exposed to the air for about an hour. It will take it some time to get a new root system fixed in the soil. The plant on the left will make a better plant and will mature fruit at least one or two weeks before either of the others.

Replanting, even when carefully done, destroys some of the roots of a plant, and for a time those that are left may be unable to supply the leafy parts with all the water they need. For this reason freshly reset plants should be kept shaded from direct sunlight for *at least* 24 hours after the replanting; in hot, dry weather a shading for 3 days may be necessary. Protection from the sunlight may be had by arranging a sheet of newspaper, lifted in the center like a wedge tent (not as a cone), with dirt or stones thrown on the corners to hold it in place; or a shingle may be thrust in the ground on the sunny side. Do not place earthen or paper pots over young plants to shade them, as this does not allow air and light to harden them properly. The plants will often become more tender when thus covered.

It is best to reset plants late in the afternoon or during damp, cloudy weather if possible. In transplanting leafy plants like lettuce and cabbage, it is a common practice to cut or shear away part of the larger leaves and thus decrease loss of water by reducing the leaf surface. Plants grown in pots, berry boxes, or dirt bands can be transplanted with very little injury to the root system.

If compelled to buy plants for transplanting, the gardener should select the most stocky plants and insist that they be carefully removed from the earth,

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Fig. 115. The effect of transplanting on the root development of celery plants. The two plants at the left were transplanted several times; those at the right were grown without transplanting.

FIG. 116. Strawberry boxes make very satisfactory covers for newly transplanted seedlings. They are light, easily packed away, and provide ventilation for the plants.

sprinkled with water, and completely wrapped to prevent drying out. They should then be replanted as soon as possible, using great care in handling them to prevent bruising. Pulling plants carelessly from flats, bruising and breaking them in handling, and leaving them to dry out before replanting will surely result in a tardy growth and perhaps failure of the crop.

The outdoor seedling bed. Seedlings for transplanting may often be grown to advantage in an outdoor seedling bed. Its location in the spring should be on a well-drained soil and in a sunny and sheltered place. The soil should be put in good condition by cultivation and by the addition of sand, lime, humus, and manure, as may be needed.

Such a bed is also of special value for starting seedlings of autumn crops of lettuce, beets, cabbages, and kale. During the late summer, seeds planted directly in the garden often fail to germinate well. In a seed bed, special care in preparing the soil, watering the seedlings, and protecting them from hot sunlight provides vigorous young plants for transplanting.

Time required to grow seedlings for transplanting. To be most successful in growing seedlings for transplanting, the gardener must have plants of suitable size and hardiness ready for planting at the proper time. The length of time required to bring plants to this condition differs for the various kinds of vegetables and for the different varieties of each kind. It also varies for a single variety according to the differences in the preparation and management of the window boxes, hotbeds, cold frames, or seed beds. The beginner can safely start the germination of seeds of cabbages, lettuce, and tomatoes from 5 to 6 weeks before the time for transplanting to the garden. Peppers and eggplants are considerably slower in growth and require a longer time. Corn, beans, squashes, and melons grow very quickly if proper conditions are supplied; 2 or 3 weeks may be sufficient for these.

FIG. 117. An outdoor seedbed. Such a seedbed is especially useful for starting seedlings for the autumn crops.

With experience, one will learn how to handle the various seedlings under the local conditions of weather and the method of treatment used. It is a good plan for the beginner to make a record of the dates of planting seed and transplanting, and of the results obtained in growing seedlings of the different varieties for transplanting. This will serve as a guide in the following seasons.

Questions

Describe the germination of a seed. What are the three main requirements for germination? Why does too much water in the soil hinder germination? Discuss the temperature requirements of different seeds for germination. Describe the proper method of laying out and planting a row of seed.

How deep should the seeds of corn, beans, and peas be planted, usually? seeds of beets, cucumbers, squashes, and melons? carrots, radishes, lettuce, and parsnip? Name some conditions that make it advisable to plant seeds deeper or shallower. When is it of special value to firm the soil? Why? When should the soil not be firmed? Why is it best not to water seeds immediately after planting?

Describe the transplanting method of starting crops. With what kinds of crops is this method used?

What is the best soil for a seed flat? Why should a very rich soil not be used? What kind of soil should be used in the flats to which seedlings are transplanted? How should it be prepared? How should the seeds be planted in a flat?

How may seedlings of the tomato and cabbage be grown in the home?

What is a hotbed? Where should a hotbed be located? What is a pit hotbed? How is it made? When should the seeds or seedlings be placed in the hotbed? What is a surface hotbed and how is it made? How should a hotbed be watered? How is it ventilated? What is a cold frame? What are its principal uses?

What is the advantage of transplanting seedlings at least once? What is the "dirt-band" method? How does it help in transplanting? What is meant by "hardening" seedlings? Why is it necessary? What points need to be especially watched in transplanting seedlings to the garden? Why do plants often need protection after transplanting? When is the best time to reset plants? Why are some of the leaves often removed when a plant is reset?

What are the advantages of an outdoor seed bed?

Things to Do and Observe

1. *To observe the germination of seeds.* Plant seeds of pea, bean, squash, and corn in flats, boxes, or pots. As soon as germination is noticed, dig up seedlings of each kind and study the various stages of germination. How does the first root get out of the seed coat? How do the stem and leaves get out? What does the root do if it emerges from the upper side of the seed as planted? What becomes of the part or parts containing stored food? How do the stem and first leaves force their way through the soil to the air above? Does the position of the seed in the soil increase or retard germination in any way?

2. *To show the effect of too little water on germination.* Fill two flats or pots with garden soil. In each flat or pot plant seeds of corn, squash, radish, cabbage, bean, and tomato. Place both in a warm room or in a hotbed. Keep *only one* watered. In which do the seeds germinate better? Why?

3. *To show the effect of too much water on germination.* Select two earthen flowerpots of the same size; or if these are not available use tin cans, preferably at least 6 inches in diameter. If pots are used, plug the opening in the bottom of one with a cork stopper; if tin cans are used, leave one intact, but make several holes in the bottom of the other one. Fill with garden soil and plant in each an equal number of seeds of beans or corn.

Keep both together in a warm room. Add the same amounts of water to each every day, so that one is kept well watered and well drained and the other is kept with free water standing at the top. In which does germination take place better?

After two weeks dig up the seeds in the one that lacked drainage and note their condition. What does this show about the amount of water that should be in soils in which seeds are germinating?

4. *To show the influence of temperature on germination.* Prepare and plant two flats as directed in 2, above. Place one flat in a warm room, and place the other out of doors or in a cool room. Give the same amount of water to each. Observe and explain differences in germination of the same kind of seeds in the two flats. Note if the seeds of the cool-season crops germinate to any degree in the flat kept out of doors.

5. *To show the importance of careful transplantation.* Watch a number of different gardeners or school-garden pupils when they are transplanting. Carefully note the methods of each. Then if you can, visit the same gardens in a few days and see how the plants transplanted by one person compare with those transplanted by another. Recall the methods of each gardener, and then try to determine from what you have observed why some of the plants grew better than others.

CHAPTER THIRTEEN

THE CARE OF GROWING CROPS

It is not enough merely to plough and hoe, and plant and sow; you must see that everything is done in proper time and order.

Old Farmer's Almanac

In caring for the growing crops, as in all garden operations, much depends on doing the right thing at the right time. In general, the best time for giving attention to a crop is before the need for doing a particular thing becomes apparent. Crops should be cultivated, weeded, and watered before they begin to suffer for the lack of such care.

Each crop grown requires a certain special treatment because of its own peculiar habits of growth, but these can best be treated in discussing the various crops. Most crops also need protection from insect and fungous pests, and the most important of these will be discussed in special chapters. However, there are certain principles which generally apply in caring for all crops, and these will be treated in this chapter. The principal divisions of the work of caring for vegetable crops are (1) cultivation or stirring of the soil between the growing plants, (2) weeding, (3) thinning and replanting, and (4) irrigation.

Cultivation of the soil. Cultivating the soil destroys weeds, which if left to grow soon cover the ground and choke even the most vigorous of the vegetable crops. It breaks up the crust which forms on the surface of the soil and allows air to enter the soil and reach the roots, and it keeps the water in the soil by making a dry, loose surface mulch. Constant cultivation is so important in

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FIG. 118. A garden in need of cultivation. The surface crust should be broken to admit air more uniformly to the roots and to conserve the soil moisture.

preserving a sufficient supply of water for plants that we should thoroughly understand how a surface layer of fine, loose soil keeps the water from escaping into the air.

How a dust mulch prevents loss of water from soil. The water in the soil can travel in any direction by passing from particle to particle, just as oil travels up the wick of a lamp by passing from thread to thread. It moves from the places where it is most abundant to the places where there is less of it; hence, when the surface layers of the soil dry out, the water in the damper soil below creeps up toward the surface. In this way the water in a soil is brought to the surface and evaporated into the air.

But if the surface layer of the soil is cultivated, it is broken loose from the soil below. Then the water finds no direct path from particle to particle upward; the connection of the upper layer with the soil below is broken. Hence the surface soil soon dries out because its supply of water from below is cut off. This dry surface layer then covers the soil below like a heavy cloth spread on the ground.

Beneath a good surface mulch of dry soil the earth is moist, even after long periods of dry weather; and when a soil in good physical condition (see page 58) is kept moist in this way it remains loose so that the roots can easily penetrate it. Thus the mulch not only saves the water for the plants, but it keeps the soil in good physical condition for the roots.

When to cultivate. Rainfall and surface irrigation destroy a surface mulch. Hence the garden should be cultivated soon after each rain or irrigation. If one waits several days, a dry crust will form and the surface will become cracked and broken up into coarse lumps. Much water is lost in this way; also such a soil is in poor condition for the roots.

Shallow cultivation should begin as soon as the seedlings are above the ground, and if seeds are slow in germinating, as are parsnips and carrots, the soil should be stirred before the plants are up. Crops need more careful and more frequent cultivation while they are young than they do later, for the roots are nearer the surface and the soil is less shaded; hence the roots are more exposed to the drying effects of the sun and air.

In cultivating young crops, work the rake or tool used in such a way that fine loose dirt is thrown about the base of seedlings or even over seedlings that are not yet above ground. Cultivate after each rain as soon as the soil is dry enough not to stick to the tools. Do not draw the cultivating tools so close to plants that the main root is touched. Fleshy roots like beets and carrots, especially, may be injured in this way.

Tools for cultivating. In cultivating the small garden, short-handled weeders with claw-like teeth, midget and longer-handled prong cultivators, hoes, and garden rakes may be used. For the larger garden a wheel hoe with various cultivator attachments is an excellent tool. In still larger gardens horse-drawn or tractor cultivators may be used.

All these tools should be used so as to stir and break up the surface of the soil. A depth of 1 inch is usually enough to cultivate; certainly one should seldom go as deep as 2 inches. Such shallow tillage does little injury to the roots of growing crops. It is important always to cultivate at about the same level, for the feeding roots of most crops reach near the surface and *deep* tillage (to a depth of 3 inches or more) after shallow tillage may destroy many roots and thereby check the growth of the plants.

The best tool for surface tillage is a garden rake. No other hand tool can do the work as effectively unless the soil becomes much compacted; then the hoe or the Norcross weeder is better. When the crops are growing in rows that are too close together to permit the use of an ordinary garden rake, a small steel rake, 4 or 6 inches wide, with numerous short teeth, is most useful. If it is fitted with a long handle, the work can be done rapidly and without much stooping. Shallow surface cultivation is of course very necessary in periods of dry weather, in order most fully to check the loss of water from the soil.

Van Evrie Kilpatrick

FIG. 119. "Thorough and clean culture is the watchword of the successful gardener." *Old Farmer's Almanac*

Weeding. If a garden is properly tilled for maintaining the surface mulch, weeds never get large enough to become a menace, at least between the rows. Weeding, therefore, becomes simply the task of pulling by hand the weeds that appear close to the growing plants. Such weeds should be pulled when they are small, before they crowd and shade the growing plants and rob them of water and food materials. If for any reason the weeds do become large, special care should be taken in removing them so that the roots of the growing crops are not injured. Weeds of large size may be cut off just below the surface.

The roots of a weed (or of a vegetable that stands close beside other plants of the crop) are often much entangled with the roots of a plant that is near it, and by

FIG. 120. When the soil is dry, the row should be watered before thinning.

careless weeding or thinning, the roots of the plant may be badly broken and loosened in the soil, so that the plant will have a great part of its water supply cut off. Hence weeding is best done at a time when the soil is moist, or even quite wet; and it is best to do the weeding on cool days or in the late afternoon, especially if the crops have become tender and weak through much shading by weeds. If such precautions are not taken, crops may be severely checked in their growth. It is the using of common sense in such matters that makes one person a more successful gardener than another.

Thinning. Crops that are grown from seed sown in the garden often need thinning. The roots of individual plants need room to spread and feed in the soil, and the leaves need plenty of room in the air. Crowded plants always grow poorly. Thinning should be done *early*, so that the young plants may be properly spaced *from the* *first.* The same sort of care that is exercised in weeding should be employed in the thinning.

Plan to give room according to the particular need of the plant. Radishes require less room than salsify and parsnips; tomatoes require more room; corn and the various vine crops still more.

The thinning of some crops, as beets and carrots, may be delayed until some of the plants are large enough to be used as food. In thinning beets for use as greens, it is often best to cut off the roots rather

FIGS. 121 and 122. Thinning corn and onions. It is well to plant thickly because in this way a full stand is insured; but the beginner often makes the mistake of allowing too many plants to remain in the row.

FIG. 123. Watering in the wrong way and at the wrong time. The water is being sprayed over the plants in the middle of the day. In consequence much of it will evaporate without reaching the roots of the plant. The soil and not the plants should be watered, and this should be done later in the afternoon or on a cloudy day.

than to pull them, to avoid loosening the plants left standing.

Replanting. Seed may germinate poorly, or seedlings may die from such causes as improper care, or the attacks of animals and insect or fungous pests. This gives a poor stand. The vacant areas in the rows should be filled by replanting with seeds or with young plants of the same or even of some other crop. In this way every bit of the garden may be kept occupied. In replanting, it is often advisable to use a quick-growing variety that will mature not far behind the first planting; but if the growing season admits of it, various other vegetables may be planted as companion or follow crops.

Irrigation. In humid regions the natural rainfall is such that there is seldom a complete failure of all crops. In arid regions the rainfall is not sufficient to support any crop, and the necessary water must be supplied through some sort of irrigation. But provision for irrigation is also highly desirable in humid regions, for here it does not always rain when the crops need water. Periods of drought occur at some time nearly every year, during which time the plants suffer, their rapid growth is checked, their qualities of tenderness and good flavor are greatly impaired, or possibly they may fail completely to produce a crop. Therefore it pays the gardener to have ready some means of supplying water whenever it may be needed.

FIG. 124. The right way to water. The water is directed to the soil about the roots of the plants.

For watering flats, hotbeds, and cold frames, and for watering at time of transplanting, the sprinkling can is sufficient. But only a very small garden can be watered in this way.

A hose fitted with a spray nozzle and connected with a city water supply, a tank, or a force pump gives excellent results. Various sorts of lawn sprinklers, "water witches," and ring or shower

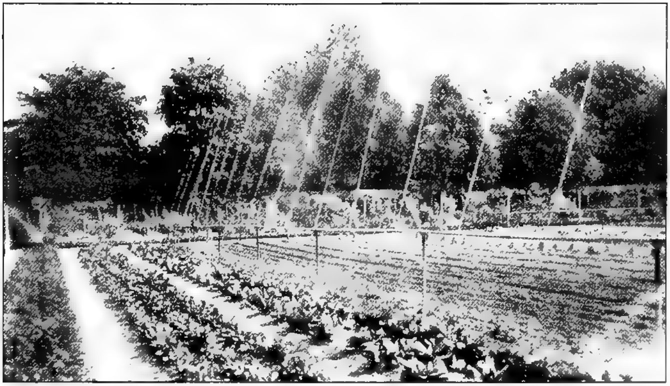

FIG. 125. Usually when irrigation is spoken of we think of the dry region of the West, but this photograph shows the Skinner system of overhead irrigation in action on a New Jersey truck farm. With a system of this sort the gardener has no fear of dry weather.

sprinklers may be attached to distribute the water in a manner like rain.

When there is a supply of water under pressure, the overhead or Skinner system of irrigation is well adapted to the needs of the home garden. This system consists of galvanized iron pipe into which holes are drilled and fitted with fine brass nozzles. One end of the pipe is closed; the other is connected with the water supply. When in action, the water spurts from each nozzle in a fine stream to a considerable distance. The pipe can be turned with the row of nozzles at various angles until areas on both sides of the pipe are well watered. A portable support and hose connection will enable one to shift the pipe as needed, or several lengths of pipe sufficient to cover the entire garden may be attached to rather permanent supports.

If the garden slopes somewhat, shallow trenches may be made between the rows of plants with a hoe, and then water may be allowed to run along these trenches as needed. In arid regions this method of irrigation is in very general use.

Whatever method of irrigation is employed, it is best to soak the garden thoroughly at intervals of several days rather than to water slightly at rather frequent intervals. As soon after irrigation as the soil is sufficiently dry, go over the garden with a rake, making a fine surface mulch.

In watering crops with hose or sprinkling can, avoid applying heavy and continued streams that wash the soil away from roots, exposing them to the air. Soil may be packed and puddled also by careless watering. Leafy crops like lettuce often decay and rot if the head is filled with water.

Questions

In what three ways does surface cultivation benefit growing crops? What is a dust mulch? How does it prevent loss of water from the soil? Why is it necessary to cultivate soon after each rain? How should young crops be cultivated? Name the best tools for cultivating a small garden.

Why is it best to pull weeds when they are small? When is the best time to do weeding? Why is this the best time? Why do crops need thinning? How is it best done? Why should vacant places in the rows be replanted? When is the watering of gardens necessary? Describe the proper methods of supplying water.

Things to Do and Observe

1. *To show that a dust mulch retains water.* Procure two deep water-tight tin cans of the same size. Fill both with clay soil, and water each thoroughly. Let stand until the soil can be worked.

Then make a good mulch on the surface of one, leaving the other as it is. Now weigh each accurately, recording the weights. After about a week weigh each again, and compare the weights with first weighing. Which has lost more in weight? Why?

2. *To determine the best time for pulling large weeds.* Two boys started a garden together in the spring. They kept it in good condition, but went to the seashore during July. When they returned, they found many large weeds shading and crowding the vegetables. One boy said: "Let's take out the weeds right away. They're shading the vegetables and taking the water from them." "No," said the other, "that will not do at all. The weather's hot and dry, and if we pull the weeds now we'll break the roots of the vegetables all to pieces and they'll wilt for lack of water. We must wait till it rains." They consulted a gardener, who advised them to cut the weeds off and cultivate with a hoe but not to pull them during dry weather. Who do you think was right?

Plant three hills of bush beans with four plants close together in each hill. After they are well grown, try thinning to one plant in a hill by each of the above methods, studying the results in each case.

3. *To show the effects of thinning.* When you plant your radishes, plant 3 feet of the row very thickly, and do not thin. Plant and thin the rest of the row according to directions. When the radishes are ready to gather, pull up the crowded plants and also a yard of the row that has been thinned. Count the number of edible radishes in each lot and compare. From this experiment, would you say that thick planting gives greater or less yield to a given space? Observe the gardens in your neighborhood and determine whether too wide spacing or crowding of vegetables is the more common.

CHAPTER FOURTEEN

ROOT CROPS AND HOW TO GROW THEM

> Say what you will of roots and the root crop, I like to have a good lot of them for winter use. I would not do without them for twice their cost.
>
> *Old Farmer's Almanac*

THE radish, turnip, rutabaga, beet, carrot, parsnip, and salsify are the principal root crops commonly grown in vegetable gardens. While these plants thrive best in temperate regions, they are all grown successfully in our southern states during the cooler months of winter and early spring. The sweet potato is another important root crop, but it is not adapted to the shorter growing period of the more northern states.

Root crops are very important vegetables. In the first place, they yield abundantly. There are 400 or 500 plants in a row of carrots or beets 100 feet long, and these crops often yield at the rate of 600 bushels to the acre. The yield is high also in the other root crops.

In the second place, root crops, taken together, are available for use during practically the whole year. Radishes are the first vegetable ready for the table from seed planted in the spring. Beets and carrots are long-season crops, but the young and partially grown roots may be pulled for use early, thus much extending the period of harvest for the crop. Radishes and turnips can be grown in the fall as well as in the spring, and in the autumn the surplus of all root crops may be stored for winter consumption. Parsnips and salsify can be dug for use, during autumn and spring, and also during winter when the ground is not frozen. These root crops have a special value because they supply vegetables to the table in winter when other fresh foods are scarce.

A good soil needed for root crops. As a rule, the root crops are " light feeders." This is because the root system is not extensive. The main root grows down rather deeply but becomes thick and fleshy, while the smaller, fibrous, feeding rootlets are not so numerous and so widely spreading as in many other crops.

Root crops, therefore, thrive best in a mellow soil in which the roots can go deep. A rich and well-watered loam or a sandy soil that contains considerable humus and well-rotted manure is best for them. On heavy and compact soils the roots of these crops are often small, ill-shaped, knotty, and more or less branched. They often fail on " raw " or previously uncultivated soils, but with good tillage and the addition of humus and manure such soils become suited to all the root crops.

Root crops maturing during periods of hot, dry weather are likely to be woody and of poor flavor. This can be prevented in large degree by supplying an abundance of water.

Thinning root crops. The beginner often fails to thin root crops sufficiently. The tops of these plants as a rule are small compared to the underground parts, and they are likely to be left so thick that the plants do not have room to mature properly.

In thinning these crops it is best to allow a distance between plants twice the diameter of a mature root. Thus radishes, which are 1 inch in diameter when mature, should stand 2 inches apart, and turnips, which are 3 inches in diameter, should stand 6 inches apart. If there is plenty of space, twice this distance may well be allowed; but in a small garden the plants should be grown as close together as practicable.

RADISHES

There are spring, summer, and winter varieties of radishes. The spring sorts are very easy to grow, but one is less certain of success with the summer and winter varieties. Rich soil, abundance of water, and cool weather favor rapid growth, which makes the roots crisp, tender, and juicy. As spring and summer radishes remain in good condition for eating only a short time they are often overplanted.

FIG. 126. Radishes grown as a companion crop with onions. When planted with another crop, radishes usually break the soil first, making it easier for the other seeds to push up, and they are soon out of the way.

Spring varieties. The planting of spring radishes may begin as soon as the soil can be worked. Some varieties are ready for use in 20 days from planting. Plant the seeds rather thickly, $\frac{1}{2}$ inch deep, in rows 10 inches apart Begin to pull the largest roots as soon as they are large enough for use.

Spring radishes are best when about two-thirds grown. They should be gathered promptly, as they soon become hollow, pithy, dry, and of strong flavor. The roots of some sorts are well below the surface of the soil, and the leaf growth is rather sparse. The beginner is likely to leave these plants in the soil too long. The size may be determined by carefully feeling in the soil about the root of a plant with the finger.

During the winter months the spring varieties may be forced in hotbeds throughout zones F and G, or in cold frames in zone E, and they may be grown in the open in zones B, C, and D. (For map of zones, see page 158.)

The *Scarlet Globe* (globe-shaped), *French Breakfast* (oval or olive-shaped), and the *White Icicle* (long, finger-shaped) are excellent standard sorts to be recommended for any section of the United States.

Summer varieties. Summer radishes are somewhat resistant to the stronger sunlight, warmer temperatures, and drier conditions of summer months. The seed is planted in the early or late spring, and the roots are ready for use in about 50 days. Success with these varieties depends on supplying the conditions that favor rapid growth. Rich soil, abundance of water, and partial shade (the latter may sometimes be supplied by a screen of thin cloth or laths) are necessary where the summers are rather warm.

Chartier and *White Strasburg* are considered the best of the summer radishes.

Winter varieties. Winter radishes require about 75 days of rapid growth to mature roots of large size. The seed is therefore planted during the summer (in July in the more northern states of zone G, about August 1 in zone E, and September 1 in zone C). The roots can thus mature in the cool weather of autumn. Before the heavy frosts occur, the roots should be pulled and placed in soil or sand and stored in a basement or a storage cellar.

The *Celestial* (or *White Chinese*), the *Long Black Spanish* (especially good for storage), and the *Sakura-jima* (or *Mammoth Japan*) are standard varieties.

TURNIPS

The turnip is essentially a cool-season crop. The different varieties are ready for use in from 45 to 70 days, and the earliest sorts are usually those grown as spring crops. There are about 20 varieties in cultivation. Of these, *Early Purple Top Milan*, maturing in about 45 days, and *White Globe*, maturing in about 70 days, are standard varieties suitable to nearly all parts of the United States.

Growing turnips as a spring crop. In many localities spring turnips are not a success because hot weather comes before they are large enough for use, and they soon become woody and bitter. But in localities having cool and moist summers, crops maturing during summer are often of fine quality. For these crops lay out the rows 12 inches apart and sow seed in the furrows ½ inch deep.

The beginner should attempt to grow only the very earliest sorts as a spring crop. Two sowings, each a row 15 feet in length, will probably be sufficient for the family needs.

FIG. 127. Pulling young beets. The beets are large enough for use and the leaves are still tender.

The autumn crop. Seed for the autumn crop is sown during July and August in the northern states and later in the South (about 15 days later for each planting zone).

In the small garden where space is limited, seed may be sown among corn to mature as a follow crop. First, make a finely pulverized seed bed by thorough raking. Then sow the seeds broadcast and lightly rake them in or plant them in rows as in the spring. Supply water if there is scant fall of rain. Cut and remove the cornstalks as the ears are harvested.

Turnips are not injured by mild frosts, but the roots should be harvested and properly stored before they become frozen. In many sections of the southern states, from Florida to California, turnips can be grown in the open during the winter so that the roots are maturing from October until April.

RUTABAGAS

Rutabagas or " Swedes " are grown much the same as fall crops of turnips, but as they require about 90 days to reach maturity, the seed should be planted three or four weeks earlier in summer. The best crops are produced in the northern states in sections having cool summers. The roots are larger than turnips, and they keep somewhat longer in storage than do most other root crops. Rutabagas are much used for feeding stock and poultry, and they are excellent food for human beings. They are especially pleasing in a " boiled dinner." The *Improved Purple Top* and the *Golden Heart* are excellent varieties for the family garden.

GARDEN BEETS

Seed catalogues list about 12 varieties of table beets, differing to some extent in shape, color, size, and flavor, as well as in the time required for proper growth. Although these beets are to be classed as essentially cool-season crops, they thrive during summer, especially in the more northern planting zones.

For the first planting, sow seeds of an early variety like *Crosby's Egyptian* about the time of the latest frost. This will furnish tender, partly grown roots for use during summer. Successive plantings of this variety may be made for later use, but the latest date of planting should be about 60 days before the first killing frost of autumn.

In the lower altitudes of the southern parts of Arizona and California and in the Gulf States, seeds sown in September will yield roots that may be left in the ground all winter and used as desired. Proper plantings in the northern states will supply the table throughout the summer and give roots for storage.

The seeds are planted about 1 inch deep in rows that are from 10 to 18 inches apart. What is ordinarily called a seed of the beet is really a cluster of tiny seeds, several of which may germinate into plantlets that crowd one another. Thinning may be delayed, however, until the young plants are 3 or 4 inches tall, when they may be used for greens. In thinning, care should be exercised so that the plants left standing are not rudely disturbed; it is often a good plan to cut off the plants to be removed rather than to pull them.

Very young plants removed in thinning may be transplanted to fill out any vacant places in the rows. Plants may be left 1 inch apart at the first thinning, and later every other plant may be removed for use as greens, leaving the others well spaced for more mature development.

The *Detroit Dark Red* is a variety widely grown as a main and late crop for storage. The roots are globular and about 3 inches in diameter. About one third of the root grows above ground, and this part is often tough and cordy. The *New Century* (also called *Rajah*, *Winter Keeper*, *Green Top*, and *All Season*) is a rather new variety that promises to be valuable for autumn crops.

CARROTS

Carrots have practically the same planting dates, heat requirements, and length of growing season as beets.

The varieties called *Early Scarlet Horn* and *French Forcing* are excellent for early crops but yield small roots. The varieties with larger roots require about 80 days for maturity but give much greater yield. They should be planted for the main or late crop. *Chantenay*, *Danvers Half Long*, and *Improved Long Orange* are all excellent.

FIG. 128. Thinning young carrots.

The small seeds of the carrot should be planted about ½ inch deep in rows about 12 inches apart. The seeds germinate slowly, and it is often 2 weeks before the seedlings are well above ground. Gardeners frequently scatter seeds of early radishes with the seeds of the carrot. The radishes mature in 20 to 30 days and are removed about the time the carrots need to be thinned to stand about 1 inch apart. Further thinning is necessary; this may be done by removing the larger roots as soon as they can be used for food. The young half-grown or "baby" carrots are one of the garden's best delicacies.

The slow germination of the seeds of carrots, and also of parsnips, and the small size of the seedlings make weeding among them difficult. It is often advisable, therefore, to cultivate the rows before the seedlings are up. This can be done by drawing a fine-toothed rake quickly along between the rows in such a manner that a thin layer of fine dirt is thrown over the planted seeds. This not only covers small weeds, but it keeps a crust from forming on the soil and makes it easier for the little plants to push through.

PARSNIPS AND SALSIFY

These two crops are the most hardy of the standard root vegetables. They are long-period crops, requiring for best development about 5 months of continuous growth. In the northern states the seed is planted as soon as the danger of frosts is past, and the roots are ready for use in late autumn. They may be dug and stored in the fall, or they may be left in the ground and dug as needed during the winter and early spring. The roots must be used before warm weather arrives, however, for then the flower stalks are produced and the roots become worthless as food. In the South these crops are not much planted, but they can be grown if the seed is planted rather late in summer.

The long taproots of the parsnip and salsify develop best in deep, loose soil. Careful spading to a depth of 8 or even 10 inches is advisable. It is sometimes stated that a development of large, well-shaped roots is promoted by making a hole a foot deep with an iron bar, filling the hole with loose, rich earth, and then planting the seed at the top.

Parsnip seed is very likely to germinate poorly, and if more than one year old, it may fail entirely. It is a good plan to sow the seed rather thickly. The plants should be thinned until they stand 3 inches from one another in rows at least 12 inches apart. Salsify is less rank in leafy growth and can stand slightly closer than 3 inches in the row.

The so-called *Sandwich Island* variety of salsify is the only sort widely cultivated in America. The *Hollow Crown* is the best variety of parsnip to plant; the variety *Early Round* has short, top-shaped roots of good flavor but of such small yield that it is not to be recommended for the home garden.

HORSE-RADISH

Horse-radish is a perennial plant that thrives best in rich loam soil. The roots are grated fine and used as a relish and condiment. Roots for use during autumn and spring may be dug as needed; those for use during winter can be stored in sand and placed in a cool cellar.

New plants are always started from roots rather than from seeds. When digging roots for table use, spade deeply, breaking up the root clusters and removing the largest. New plants will arise from the small roots left in the soil. A few hills will provide a family with a sufficient supply of horse-radish.

SWEET POTATO

Sweet potatoes are grown successfully as a field and garden crop as far north as the upper parts of zone E.

The stems trail over the ground and take up so much space that the crop is not well suited to gardens of small area. It is, however, an important crop in many of the large-sized home vegetable gardens of the South.

The sweet potato thrives in a warm, sandy, and well-drained soil. Little rainfall is needed after the growth is well under way; in this requirement it differs from the other root crops we have discussed.

The sweet potato plant is propagated by "slips" or "draws." Roots are placed about 4 inches deep in sand or soil in flats, or directly in the soil of hotbeds, and kept moist and warm. Many shoots or draws develop from an old root, and these in turn develop roots and form young plants suitable for transplanting into the garden in about 5 weeks.

In the South cuttings are taken from the vines of growing plants and used as plants for later plantings. The crop is grown in rows, and the plants are most often set on low ridges; but on sandy soils flat culture is used.

The roots should be dug before severe frosts occur. They should be allowed to dry in the sunlight for several hours, and then be placed loosely in baskets or slatted crates and dried or cured in a warm room (beside a kitchen stove or furnace will do) for a period of about 10 days. They may then be stored in a dry place where the temperature does not go below 50°. The roots should be handled carefully, as they soon rot if bruised.

Unless local conditions are found to be unfavorable for certain of the root crops, or the family tastes reject some sorts, all those mentioned above should find a place in the home vegetable garden. All, excepting horse-radish and sweet potatoes, are grown from seed sown directly in the garden soil; hence it is easy to get the crops started.

Gardeners planning to grow the sweet potato are advised to send for Farm Bulletin 395 of the United States Department of Agriculture; also to ask for literature on propagation, culture, diseases, and varieties from their own state agricultural experiment station.

Questions

Name the principal root crops grown in vegetable gardens. Why are root crops especially important vegetables? What is meant when it is said that root crops are "light feeders"? In what soils do root crops thrive best? In what soils are root crops most likely to fail? Why should root crops be thinned? What is the general rule to be used in thinning them?

What special conditions do radishes need to yield well? What conditions are necessary to grow summer radishes successfully? When are winter radishes planted? Can turnips be grown as a summer crop in localities having hot-weather conditions? How are they grown as an autumn crop? When is thinning of beets often done? What is the best method of doing this? Describe a way to cultivate young carrots and parsnips without disturbing them. When should parsnip seed be planted in the Northern states? Describe the method of propagating the sweet potato.

Things to Do and Observe

1. *To learn which root crops are suited to your locality and the varieties of each that should be grown.* Visit as many gardens or farms in your neighborhood as you can and note the kinds of root crops grown. Inquire as to the varieties grown for home use and for market.

2. *To determine the soil best suited to growing root crops.* In your visits observe where the various root crops are usually grown. Do you ever find, for example, these crops planted on a dry hillside? If so, how do those growing in such a location thrive in comparison with those growing in rich bottom land?

3. *To determine if you have planted your crop at the right time.* Keep a record of the dates of planting for all the crops grown in your garden. Compare these dates with those in your table of planting dates and with the dates of local frost. (See Exercise 1 on page 163.)

Would planting at a different date have been better in any case?

CHAPTER FIFTEEN

CROPS GROWN FOR THEIR LEAVES

> Who would be without celery and lettuce, rhubarb and spinach, when it is so easy to raise them?
>
> *Old Farmer's Almanac*

All leafy crops of the garden are used as food when the leaves are tender and in good condition. The plants are not left to reach natural or full maturity and produce seed. They are often grown in ways that promote excessive leafy development, which may be somewhat unnatural for the plant.

Some leafy vegetables, like rhubarb, onions from sets, Swiss chard, and cabbage, are rather easy to grow successfully, but the greater number of leafy vegetables require conditions that are very favorable to their growth. In general, the production of many tender leaves in these crops requires a rich soil, abundant moisture, cool weather and good cultivation. Poor soil, lack of cultivation, insufficient moisture, and hot weather invariably result in fewer leaves, slower growth, and poorer quality.

Many of the most delicious of the leafy vegetables (especially of the salad crops) wilt quickly when gathered, and soon lose their tenderness and best flavor. For this reason they are especially suited to home production, for then they may be placed on the table fresh from the garden. With a few exceptions, home-grown leafy vegetables excel in crispness and flavor the vegetables which are bought in the market; and the excellent table qualities of properly grown leafy crops well repay the home gardener for his efforts in producing them.

At least twenty distinct sorts of plants may be grown in the home vegetable gardens in the United States solely

States Relations Service

FIG. 129. A boy's successful crop of leafy vegetables.

for the leaves which they produce. In the discussion of these various crops it is convenient to group them into classes according to the way the young plants are started and the season when the crop matures.

LEAFY CROPS PROPAGATED VEGETATIVELY

This class includes rhubarb and four bulb-like plants of the onion family — chives, shallots, garlic, and bulblet onions. With the exception of garlic, these vegetables are ready for use early in spring. Chives and the bulblet onions are hardy perennials that may be left in the ground during the winter.

Rhubarb or pieplant. This plant thrives anywhere in the United States except in the lower planting zones. In the northern sections it is a long-lived or perennial plant, and if planted on a well-drained soil, it withstands very severe winters. Early in spring it throws up a crop of leaves with thick, fleshy leafstalks. The stalk portion of the leaves when properly cooked makes a tart sauce whose acid flavor is decidedly appetizing in early spring. In the more southern parts of the United States the plant runs quickly to seed and usually dies during the summer; hence it is not well suited to culture there.

The acid flavor of rhubarb is due to the presence of oxalic acid, but this acid is so diluted in the fleshy leafstalks that their use as food does not cause poisoning. It is not safe, however, to eat any part of the expanded, less fleshy portion of the leaf.[1]

Rhubarb forms large clusters of roots, and the plant is usually propagated by digging up and dividing these clusters. The plants should be set about 4 feet apart each way, and the plot kept well cultivated. Add about 3 inches of well-rotted manure late each autumn and spade it under early in the spring.

When left alone the roots become crowded, and in consequence the leafstalks are small and slender. To prevent this, the plants should be divided and reset in the autumn of every third or fourth year. Dig up the root clusters and select for transplanting only good roots with a well-formed bud or "eye." As the resetting reduces somewhat the yield for the first year, it is a good plan to transplant only half the bed at a time.

[1] The garden sorrel (*Rumex acetosa*), a near relative of the rhubarb, is sometimes cultivated and sold in the markets for use as early spring greens. It produces considerable amounts of oxalic acid, and has sometimes caused death.

Fig. 130. Rhubarb along the edge of a garden. The photograph shows the "barrel method" of covering the plants to make the stems longer and more tender. Every other barrel was removed before the picture was taken.

No leaves should be pulled the first year after resetting.

Roots for starting a bed may be obtained from seed houses or perhaps from a neighbor's garden. The standard varieties known as *Victoria* and *Linnæus* are the best sorts.

Rhubarb may be grown from seed also. Sow the seed early in spring in rows 1 foot apart in a seed bed. Thin to about 6 inches apart in the row, and when the plants are a year old transplant them to a permanent bed.

The outer leaves of the rhubarb are pulled for use as soon as they reach proper size. Break them off by a quick side twist and jerk. Later in the season allow plenty of the leaves to remain so that they may furnish food to the underground parts. The plants will be more vigorous if the flower stalks, which appear in the early summer, are cut (not broken) as fast as they form.

Chives. Chives are hardy perennials having small, onion-like bulbs and narrow, hollow, erect leaves 6 or 8 inches in length. Left alone, the plants multiply rapidly and soon form dense mats. They are readily propagated by dividing and replanting the clumps in spring. A bunch of living plants for the first planting may be obtained from a seed firm. The plant will thrive in any garden soil. The leaves, which are used in seasoning salads, stews, and soups, may be cut repeatedly, as they come again quickly.

In the northern states the plants will furnish green leaves during the winter if clumps of them are dug in late autumn, placed in flats, and given the protection of a cold frame or a spent hotbed.

Shallots. The mature or resting plant of the shallot consists of a number of elongated and gray-colored bulblets (usually called "cloves") attached at the base to a common stem. These cloves are separated and planted with the stem-end down. In the North, planting is done in the spring; in the South, it is usually done in the autumn. Each clove quickly makes a leafy growth and is soon ready for table use.

If left undisturbed the basal bulb splits up into a number of new cloves. These clusters may be cured like bulb onions and stored for winter use or for planting the following spring. Shallots are milder in flavor than most onions and are easily grown. They are deserving of more general culture in home gardens.

Garlic. The mature garlic bulb consists of a number of small bulblets or cloves, each of which is inclosed in a thin, dry, tough leaf; the whole cluster is in turn inclosed within a larger dry leaf. The cloves are separated and planted in early spring, the plants continue growth during summer, and the mature bulbs are harvested in autumn. The dry tops, which are tough and stringy, are braided together, and the string of bulbs is hung up in a dry place. Garlic has a strong flavor and is used principally in flavoring stews and salads. It is well adapted for growing in the warm sections of the United States.

Bulblet onions and their culture. In these onions the mother plant produces small bulbs or bulblets and seldom flowers and seeds. There are two sorts of bulblet onions, commonly known as (1) *multiplier* and *potato onions*, in which the mother bulb itself splits up into bulblets, and (2) the *Egyptian* or *perennial tree onion*, which not only divides at the base but also produces erect stalks at the tops of which new bulblets develop. The bulblets of multiplier and tree onions are quite similar in structure to the onion sets grown from seed. Not all seed firms list the sets of these onions, but they may be had from some firms.

Multiplier onions planted in autumn and left in the ground over winter begin growth very early in the spring. Almost before the ground is thawed out, the bulblets begin to produce leaves and may then be pulled for the table. If left alone, each bulblet becomes a compound bulb composed of new bulblets. Unless well thinned by pulling during the spring, the bulbs and bulblets should be separated and replanted in autumn to prevent crowding.

Tree onions also live through severe winters without injury. The basal or mother bulb divides, making tender young plants suitable for use in early spring. If left alone, the plants may later produce erect stalks on which a cluster of new bulblets is produced. These may be planted in autumn to raise another crop of leafy plants in the following spring.

The various bulblet onions furnish, as do chives, fresh leafy food suitable for table use during spring, when the green parts of the leaves as well as the basal parts are tender, juicy, and of good flavor. They are then pulled, cleaned, and eaten raw as a relish. In the markets such onions are commonly sold in bunches; hence they are often called "bunch onions." Later in the season the leaves become tough and of strong flavor. The bulblets themselves are usually too small to be of much value as "dry" onions, but they are about the right size for use in pickling.

LEAFY CROPS GROWN FROM SEED

The leafy crops that are grown from seed may be grouped into several classes, as follows:

(1) The bulb plants, such as seed onions and leeks.

(2) "Cut-and-come-again" crops that begin to yield leaves early in the summer, like parsley, yellow rocket, Swiss chard, and New Zealand spinach.

(3) The long-period cool-season crops that mature in autumn, like endive and chicory.

(4) The forced cool-season crops, including celery, the cabbages, and head lettuce.

(5) The short-period crops, such as leaf lettuce, spinach, peppergrass, and mustard.

BULB PLANTS GROWN FROM SEED

Seed onions and leeks are the two bulb-like garden vegetables of this general class. In seed onions the leafy growth is rapid during the cool weather of spring, but with the arrival of hot weather the tops of the leaves die, the growth stops, and the fleshy bases of the leaves form a bulb which " rests " for a time; in this condition it is called " dry." In the leek the bulb portion does not become much enlarged, but the lower portion of the leaves forms a column of fleshy and edible tissue. The leek grows rather slowly during the hot summer, but makes a rapid development during the cool season of autumn.

Leeks. The leek is a biennial plant. The crop is best grown from seed sown early in the spring in outdoor seed beds. The plants should be transplanted to the garden when 6 or 7 inches tall, being placed 4 inches apart in rows spaced at 12 inches. When transplanting, set the plants deeply — almost to the young center leaves — so that the column of leaves will blanch in the soil. If set lower than this, especially in heavy clay soils, the heart may fail to develop further.

When the crop is grown from seed planted in the row, a little soil should be raked up around the leaves from time to time as they develop. In the northern sections plants may be covered with straw and left in the field for use during winter, or they may be dug and stored in earth

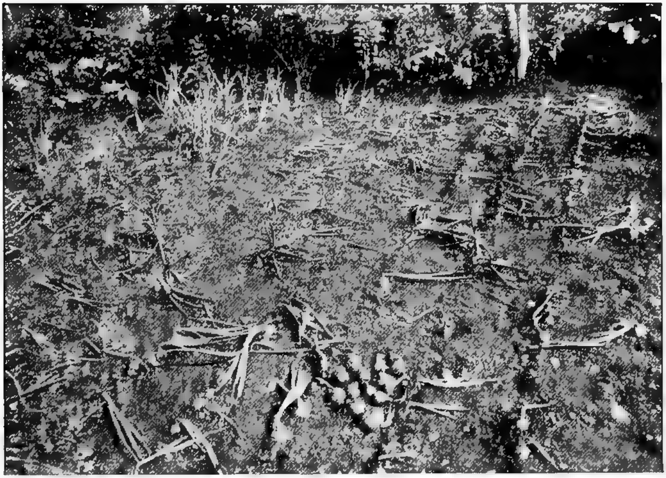

FIG. 131. "Dry" onions grown from onion sets. They are now ready to be pulled, dried, and stored away for the winter.

in a cool cellar or in a cold frame. In the South the crop may be left in the garden for use as needed.

The green leaves of the leek have a coarse texture, a rank odor, and are strongly acrid when eaten raw. The blanched portion is more tender and less acrid. When the leek is cooked, the flavor is even milder than that of most onions; hence the plant is excellent for flavoring soups and stews. There are not many varieties of the leek offered by seedsmen. *London* or *American Flag* and *Large Rouen* are standard sorts.

Seed onions and their culture. If the seed of these onions is planted in spring and the plants well cared for, each plant forms a large bulb or "dry" onion before autumn arrives. When properly cured and stored,

FIG. 132. When onions are about two-thirds grown, the tops are sometimes broken down, as shown in this picture. By this practice the growth of seed tops is checked, the size of the bulb is increased, and hollow centers are not so likely to form within the bulb.

these bulbs may be used as food until late in the following spring. If these one-year-old bulbs are planted in spring, they produce tall stalks bearing flowers, and later, seeds; then the mother bulb dies. Seed is thus produced in the second year of the plant's growth, and for this reason the onion is a biennial.

If, however, the seeds are sown late, or the young plants are much crowded, or are grown on poor soil, the plants do not form large bulbs that year. Instead, the tops die in summer, leaving only small bulbs that are called "sets." If these sets are planted early in the following spring in rich soil with sufficient room, the plants grown from them will make large "dry" bulbs. These, if stored through the winter and planted the following season, will produce seed. Sets are therefore plants that are halfway to the dry onion stage of development; and if the conditions for growth are unfavorable the first year, the onion takes three years to complete its entire life cycle.

Dry onions for table use may therefore be grown in one season, either from seed or from sets. Although onions grown from sets are inclined to shoot to seed, the crop is more easily grown from sets than from seed. They make a much quicker start, and the production of bulbs of large size is somewhat more certain. It is well to buy sets of named varieties rather than to buy simply "sets." Red sets of the *Red Wethersfield;* white, of *White Portugal;* and yellow, of *Yellow Danvers,* — are recommended for general planting. Sets are planted early in spring.

Something like 30 varieties of onions grown from seed are often listed by seedsmen. *Southport White Globe, Southport Yellow Globe, Southport Red Globe, Danvers, Prizetaker,* and *Red Wethersfield* are good varieties for all sections of the United States. The *Queen* or *White Pearl* is an early, small, flat, white onion excellent for pickling. The Bermuda onions (*White Bermuda, Red Bermuda,* and *Crystal Wax*) are good mild-flavored sorts.

In growing direct from seed, sow thickly in rows 12 or 14 inches apart, as soon as there is no danger of frosts. The young plants are slow in getting a start. Cultivate well, and keep weeds out of the rows. Thin to stand 1 inch apart in the row, and later remove every other plant for use as young onions, leaving the plants for dry onions spaced about 2 inches apart in the row.

Larger bulbs and earlier bunch onions may be had by starting plants in a hotbed, cold frame, or indoor seed bed. In doing this, sow seed about 10 weeks before planting time. Transplant once to other flats as soon as seedlings are 2 inches tall, and space them so that they are about 1 inch apart. As soon as frosts are over, harden the seedlings and transplant them to the garden.

In the South, seed is very generally planted in the autumn and the crop grows during the mild winter. Even in some sections of the northern states, seed may be sown in the early autumn; the young plants live over winter and start growth early, yielding an early crop of bunch onions, or later, dry onions.

All onions require a rich and well-drained soil. Success in growing good dry bulbs from seed depends on sowing the seed as soon as possible in spring, on thinning early so that the growing plants are not crowded, on keeping the weeds from even making a start in the onion plantings, and on frequent but shallow surface cultivation. With this treatment, the plants make rapid growth during the cool spring season and form bulbs of good size. It is, however, somewhat difficult to grow good bulbs in localities where the summers are cool and damp, for in such places the plants tend to remain green and leafy.

The proper maturing of onion bulbs depends on the weather and upon their treatment. If the bulbs reach a good size by the time hot weather arrives, the tops turn yellow and begin to die, and the bulb enters a resting condition. The bulb is, of course, still fleshy and juicy inside, and it contains at least one living bud or "heart." As long as this bud remains dormant, the bulb "keeps"; but if it resumes growth, the bulb soon becomes useless as food.

FIG. 133. Parsley grown in a cold frame for use in the late fall and early winter months.

The bulbs should be pulled as soon as the tops turn down and begin to wither. They may be left in small piles in the open air to dry for a few days, after which the tops should be cut off. The bulbs are then placed in crates or on trays and stored in a cool and well-ventilated room where they will not freeze.

In a small home garden, a short row, kept planted with multiplier or with tree onions, will supply a family with sufficient bunch onions for use during early spring. For a supply of dry onions, the seed or the sets of good seed varieties should be planted.

CUT-AND-COME-AGAIN LEAFY VEGETABLES

Parsley, yellow rocket, Swiss chard, and New Zealand spinach are crops of this class. The outer and larger leaves, or even the branches, are cut as they reach a good size, leaving the inner leaves or new shoots to develop for later use. The repeated growth of these vegetables makes them especially desirable for the small home garden, for a few plants occupying a row only 10 feet long will continue to yield a harvest of leaves from early summer until autumn frosts. With rich soil, abundance of water, and good cultivation, these vegetables will thrive and yield abundantly during the summer months.

Parsley. Sow the seed of parsley rather thickly, not more than ½ inch deep, in shallow drills that are about 12 inches apart. A row 5 feet long, containing 10 plants, will furnish an abundance of attractive leaves for garnishing throughout the summer and autumn. Plants left in the garden over winter will supply leaves for a while in the following spring, but will soon run to seed.

Plants may be potted and grown during the winter in cold frames or even in the window of the home for use when other green leaf vegetables are not readily available. The *Plain-leaved* variety is very hardy, but the *Double-curled*, the *Moss-curled*, and the *Fern-leaved* are more attractive in appearance and more generally grown.

Yellow rocket. This plant is also called "upland cress" and "common winter cress." It is a member of the mustard family and is closely related to mustard, peppergrass, watercress, and horse-radish. The leaves are used as a salad, and the plant is about the only good salad plant that will thrive during hot weather. Sow the seed early in spring; in about 10 weeks leaves will be ready for use. The plants form rather dense clusters of leaves, and if these are picked carefully the plants will continue to bear leaves. Yellow rocket will withstand rather severe frosts.

FIG. 134. Gathering Swiss chard. Only the largest leaves should be picked; the others should be left to grow.

In many parts of the planting zone E, and farther south, plants of yellow rocket grown from seed live over winter and will supply leaves until the next spring, when they soon run to seed. It is said, however, that the plants can often be kept in good condition for two or more years if the flower stalks are picked off before the flowers open.

Swiss chard. Swiss chard is a variety of beet that develops large leaves with somewhat fleshy stems. It does not have a fleshy root like that of the garden beet. The culture of Swiss chard is the same as for the garden root beets. The most satisfactory variety is the *Lucullus*.

FIG. 135. New Zealand spinach, the best plant for summer greens. The tips of the branches are cut, as shown in the picture.

The outer leaves may be cut closely at intervals from early summer until frosts. The first cutting can be made about 60 days from date of seed sowing. The plant usually lives over winter in and below zone E, but goes to seed the second year.

New Zealand spinach. The New Zealand spinach plant has recently been introduced into cultivation in America where it is proving a strong and vigorous grower. It is an excellent plant for use as pot greens.

The seeds have thick, nut-like walls and should be softened by soaking to make germination more rapid and certain. Put seeds in a dish, pour over them hot (almost boiling) water, and let stand for from 12 to 24 hours before planting. Plant seeds early in spring about 1 inch deep in groups of 4 or 5, about 3 feet apart. The plants grow rapidly and thrive all summer. The upturned ends of the branches, with several leaves, are cut for greens. New side branches are then formed, and growth is continued until the plants are killed by frost. Six hills of the plants will supply a family with one or two "messes" of tender, clean greens each week from early summer until frosts occur.

In many sections as far north as planting zone F, the plants seed themselves; that is, the seeds which fall from plants to the ground live over winter and germinate early in the following spring. These young plants may be transplanted to a place in the garden which has been properly prepared for planting.

LONG-PERIOD SALAD VEGETABLES THAT MATURE IN AUTUMN

Endive and chicory are two salad plants that mature best in autumn as cool-season crops. If planted very early in spring, they tend to run to seed during the summer, even in the more northern of the planting zones. Seeds are therefore planted in summer (in early summer in the north and later farther south). The plants grow rather slowly during hot weather, but are ready to make a rapid development during the cool autumn.

Endive. Endive is a favorite bitter salad plant, grown in the North as a fall crop and in the South as a winter crop. The seed is planted during June or July in the North and as late as in August in the South. Seed is sown directly in the garden or in seed beds for later transplanting. The plants should stand 1 foot each way in rows that are at least 1 foot apart.

Varieties such as *Green-curled*, *Moss-curled*, and *White-curled*, which produce dense clusters of curled and finely divided leaves, are very satisfactory for culture in the home garden. When the outer leaves are 6 or more inches in length, they should be drawn together and tied with soft cord or with raffia, in order to blanch the inner leaves. One variety known as *Escarole* has broad leaves and is less bitter than the cut-leaved sorts.

With the approach of freezing temperatures in the northern planting zones, endive may be stored. Dig up the plants, keeping a ball of dirt in place about the roots, and pack close together in a cold frame or in boxes that are placed in a cool cellar. Keep the soil moist, but be sure that the leafy portion is kept dry and well exposed to the air to prevent rotting. Plants can readily be kept in storage in good condition for a period of at least 6 weeks; with special care, under most suitable conditions, they may be kept much longer.

Witloof chicory or French endive. When properly grown, this plant yields a most delicious and mildly bitter salad for use during the winter months. Although easily grown, this crop has not become well known in American gardens; but it has long been a favorite salad in European countries. The variety known as the *Witloof* is especially to be recommended. In the northern states, sow seeds during June or July in shallow drills about 12 inches apart. Thin the young seedlings to stand 8 inches apart.

The green leaves produced in the field are not used as food, as are those of the curled endive, but a new crop of leaves is forced from the roots in the following manner: The roots, which should resemble those of the parsnip in shape and size, are dug before severe frosts occur. Those not needed for immediate forcing are stored in cold frames, in pits, or in a cool room of a cellar, so that they may be used for forcing during the winter. Trim the roots to be used for forcing to a length of 8 inches, and cut away the leaves, allowing a short " crown " to remain on the roots. Then set the roots, about 4 inches apart, in a box, placing earth about them to the level of the crowns. Water the soil thoroughly, and the next day add about 8 inches of clean sand. Place the box in a moderately warm cellar (a temperature ranging from 50° to 60° is excellent) and keep the sand and soil moist. In about 15 days leaves will begin to protrude through the sand, and some of the heads will be ready for use.

The same box and soil may be used for forcing successive crops. The head is a closely compacted, elongated cluster of tender and well-blanched leaves. The ease with which this delightful salad may be had during the winter months justifies its thorough trial by the home gardener.

COOL-SEASON LEAFY CROPS GROWN BY THE TRANSPLANTING METHOD

In general, celery, the various members of the cabbage tribe, pe-tsai, and head lettuce are long-period crops. To obtain good spring or early summer crops before hot weather arrives, the plants are forced by the transplanting method. The late or autumn crops are grown directly from seeds or by transplanting from sowings made late in spring, or in southern sections even in late summer. Head lettuce is usually grown best as a spring crop. Early and late crops of celery, pe-tsai, and the various cabbages may be grown, but the main crops of these mature in autumn. In many sections of the northern planting zones having cool summers, certain varieties of celery, kale, and cabbages may be grown successfully as summer crops, the earlier varieties yielding crops during the summer and the late varieties maturing in the autumn.

Celery. Celery thrives best on rich soil; it also demands much water and cool weather. In the North it is grown chiefly as an autumn crop, although in sections with cool summers, early varieties maturing in August may be grown. In the South the plant is grown as a winter crop from seed grown in late summer in outdoor seed beds that are kept well watered.

The crop is best grown throughout the North from seedlings that are transplanted twice — once from seed pans to flats, and then from the flats to the field. Transplanting leads to the formation of many fibrous roots and gives "stocky" plants. The seedlings grow slowly and need special care throughout their entire period of growth.

In the northern zones, seed of the earlier sorts, such as the *White Plume* and the *Golden Self-blanching*, may be sown as early as the first of February and the seedlings planted in the garden as soon as weather conditions will permit. The growth of seedlings is so slow that even under very good care 3 months may be required to bring them to a good size for transplanting to the garden. The main or late crop is best grown from seedlings that are ready for planting in the field about July 1. For this crop the varieties named above may be planted, or some of the varieties that are better winter keepers (such as *Giant Pascal* and *Winter Queen*) may be grown.

Celery plants are set about 6 inches apart in rows. Level culture, or setting the plants only slightly below the general level of the soil, is considered better than the older methods of trench culture.

As the plants reach a good size they should be blanched. This may be done with dirt as follows: Draw the tops closely together with one hand, and with a hoe in the other hand draw dirt up around the plants until only the tops of the leaves protrude. With the

FIGS. 136 and 137. Celery. At the left the seedlings are being transplanted from flats to the garden. At the right the mature plants are being tied preparatory to hilling up with earth. This method of blanching is practiced especially on sandy soil.

approach of freezing temperatures, more soil may be banked up and straw or leaves packed about and over the tops. Then more soil may be piled up, and a board, or two boards arranged as an inverted trough, placed over the straw. This protects from cold and keeps the plants dry. In sections with moderate winters the crop can be thus left for use as desired throughout the winter; but in the more northern of the planting zones the crop should be stored in cool cellars, pens, or cold frames (see page 346).

Blanching may also be accomplished by wrapping a collar of paper about each plant and tying it firmly in place. Newspaper may be used, but stiffer paper that keeps its position after rains is better. For blanching early crops and autumn crops that are to be stored before cold weather the use of paper bands is advised. Early crops often rot from heating if blanching with soil is attempted. Paper collars or bleachers, with special metal "handlers" that make easy the work of arranging them, may be bought of seed firms that deal in garden supplies. The use of 3-inch × 12-inch drain tile for blanching gives excellent results, and is to be recommended for blanching the home supply of early celery.

The method of "new celery culture" recently used consists of growing plants so crowded that they are self-blanched through mutual shading. The plants are set about 6 inches apart in rows that are only 8 inches apart. The soil is excessively manured; as much as 1 ton of well-rotted manure to the square rod is often used, and the plot is kept well watered continually. When thus "forced in the field," the crop is often tender and well self-blanched; but it is more subject to disease and the product is often of poorer quality than when given more room and blanched by banking with earth or by collars.

Cabbage. All cabbages are best grown from transplanted seedlings that have been grown from 8 to 10 weeks in a hotbed, cold frame, or outdoor seed bed. For early cabbages, transplant to the garden as soon as the danger of severe frost is over. For late varieties, transplant in June or July in the northern states and somewhat later southward. In the plot of cabbages shown in Figure 142, several varieties of early and late cabbages, together with cauliflower and Brussels sprouts, were planted at the same time.

In many parts of planting zones D and E, cabbage can be grown, or at least left outdoors, over winter. In the climate of northern Louisiana, the seedlings for the spring crop can be reared in cold frames from seed sown in November or December and transplanted in February; in this way the crop is harvested in April and May. Sweet potatoes may then be grown on the same plot, as a succession crop. Treated in this way in the South, the growing period of such a variety as *New* or *Early Jersey Wakefield* is from November 1 to May 1.

Plantings of early varieties, such as *Early Jersey Wakefield*, yield heads in about 90 days, or early in July in the vicinity of New York City if planted about April 1; but the heads do not "keep" long in hot weather. It is an excellent plan to plant from 5 to 10 plants each of several early and late varieties. For general culture, the following varieties are excellent: *Early Jersey Wakefield* and *Charleston Wakefield* for early use; *Early Summer* and *Succession* for midsummer; and *Autumn King* and *Danish Ball Head* for fall and winter use.

Cabbage is an easy crop for the beginner to grow. It is likely to need protection from aphids, cutworms, and the cabbage worm (especially discussed in the chapter on injurious insects). The crop may entirely fail because of plant diseases carried in the soil and for which there is no good remedy. In this case the gardener had best not attempt to grow the crop, for a time at least; or he should secure seed of varieties found to be resistant to the disease. (See Figures 172 and 173.)

Cauliflower. The cauliflower is less hardy than cabbage and less enduring of summer heat. For spring planting, the crop does best in the cool sections of the more northern of the planting zones, where the summers are mild. The plant needs a rich soil and plenty of room to grow. It is best to grow plants about 3 feet apart each way, with a low and quick-growing companion crop between. The clusters of thick, fleshy flower stalks are blanched for table use by tying the leaves together over the top. The mature heads are not readily stored for later use; hence it is best not to grow any more plants than can be used as they mature. In the North, *Early Snowball* and *Dwarf Erfurt* are excellent varieties. The *Autumn Giant* is a large-growing and late variety that is well suited to southern sections.

Brussels sprouts. Brussels sprouts are grown best as an autumn crop, but in the South they are extensively grown as an early spring crop. The plant requires a longer period of cool weather than most of the cabbages, and is more hardy. It often fails from lack of water or from excessive heat. In the North, when grown as a fall crop, the small heads of leaves or "buttons," produced in the axils of the leaves, are gathered as desired until some time after cold weather arrives; or in sections with severe winters, the plants may be dug and stored as recommended in a later chapter (20). If one succeeds in the growing of cabbage, then it is safe to try the growing of Brussels sprouts as an autumn crop.

Kale and collard. These plants belong to the cabbage group, but they have separate leaves instead of a head as the cabbage has. Kale, which is the most hardy of the cabbage group, is an excellent winter crop in the South and a late autumn crop in the North, where it may be left without protection even in rather severe winter weather. *Dwarf-curled*, *Siberian*, and *Tall Scotch* are standard varieties of kale.

The collard withstands summer heat better than kale and hence is better suited for culture in the southern planting zones. The variety known as *Georgia* is most generally grown.

Both kale and collard are often grown from seeds sown directly in the garden in rows about 2 or 3 feet apart, and later thinned so that the plants stand about 12 inches from one another in the row. The plants are left standing where grown until light freezing makes the leaves of the loose heads tender.

Pe-tsai or Chinese cabbage. Chinese cabbage is a leafy vegetable that deserves a trial in the home vegetable garden. It is generally grown as an autumn crop, but even in the northern planting zones it can be grown as a spring crop if the roots of young plants are not disturbed in transplanting.

For the spring crop, sow seed from 4 to 8 weeks before the date of the latest frost. Transplant from seed pans to individual pots of small size; transplant again to larger pots before plants become "pot bound"; then transplant to the field, *keeping the roots and earth within the pots intact.* Grow in a rich soil, and supply water in abundance unless rain is frequent. Plants of the larger varieties thus grown will often make heads weighing 7 pounds in 60 days from seed. The heads do not keep well in hot weather, hence the main crop should be grown in autumn. For an autumn crop sow seed late in July in the North and later farther South, directly in the garden. As the plants may be used when partly grown, it is a good plan

FIG. 138. A spring crop of Chinese cabbage (pe-tsai). This is a new vegetable that is the best of all salad plants.

Fig. 139. Chinese cabbage. The plate at the left contains the tender inner leaves used for salad. The outer, coarser leaves are usually cooked like cabbage, and the heavy midribs are prepared like asparagus.

to start the crop with the plants standing 4 or 6 inches apart, and then thin to 12 inches by removing every other one.

The tender, crisp, and juicy blanched leaves that compose the central portion of the head make a most excellent salad. The outer leaves of mature heads and the entire partly matured plant may be cooked as pot greens.

The plant is not a true cabbage. It has the flavor of the turnip. It is more leafy than the turnip and, it would seem, more desirable as a crop for use as pot greens, especially in the South, where turnips are quite generally grown for this purpose.

Pe-tsai is now coming into more general culture in the United States. Several varieties are known in China;

some of the smaller sorts resemble Cos lettuce in habit of growth. Undoubtedly varieties will be found or developed that are suited to various conditions and needs in the United States. The beginner can grow good crops from the seed of any of those varieties that may now be bought from seed firms.

Head lettuce. In some localities having moist and somewhat prolonged cool weather in spring, excellent head lettuce may be grown from seed sown early in the field. Much commercial head lettuce, especially of the *Salamander* variety, is thus grown in the market gardens on Long Island.

Fig. 140. Head lettuce, that was grown out-of-doors in the fall, being set out in a cold frame at the approach of cold weather.

In most home gardens, good head lettuce can be grown best in the spring by the transplanting method. In many if not most sections, heads will form only if special attention is given to every step in the growing of the crop so that a vigorous, rapid, and continuous growth is maintained during the cool weather of spring. Give seedlings plenty of room in flats (space them at least 3 inches apart) in order to obtain stocky

FIG. 141. Head lettuce ready for transplanting. On the right a seedling prepared for transplanting by the 'dirt ball" method is shown. The earth in the flat is carefully compacted about the roots, thus preventing them from being broken. The plant at the left has been carelessly pulled and has little earth on the roots. This plant may grow so slowly after transplanting that it will fail to form a head.

plants. *In transplanting, keep roots intact in a large ball of earth.* Transplant to the garden during cool, damp weather. In the garden, supply plenty of water if needed, and cultivate to maintain the earth mulch.

Some of the round-headed types, as the well-known *Big Boston*, *May King*, *Iceberg*, *Salamander*, and *Hanson*, together with *Trianon Cos Lettuce*, should be tried. The crop should be used before hot weather, for then the plants shoot up into flowers and seed.

Head lettuce makes an excellent part-companion crop with such a long-season crop as the tomato.

SHORT-PERIOD COOL-SEASON LEAFY CROPS GROWN FROM SEED IN THE GARDEN

Leaf lettuce, spinach, peppergrass, and mustard mature leaves so quickly during the cool weather of spring that seed may be sown in the garden where the plants are to stand. With rich soil, plenty of moisture in the soil, and good cultivation, these vegetables seldom fail to produce satisfactory crops.

These crops suffer especially (as do all other vegetable crops) from crowding in the row. The average gardener seems tempted to leave the plants standing closely together. It does look like a " poor scant stand " to thin the young plants to 3 or 6 inches apart in the row. But proper and early thinning not only gives larger plants and a greater total yield for each row, but the plants mature more quickly.

Leaf lettuce. Many excellent varieties of loose or leaf lettuce are listed in the seed catalogues. The seed is usually sown in rows about 14 inches apart and seedlings thinned to stand 5 to 10 inches apart. Cos lettuce also may be grown from seed sown directly in the garden, but the heads are smaller and later in developing than when grown by the transplanting method.

Spinach. From 30 to 60 days is sufficient for the development of the loose clusters of spinach leaves, so widely used as pot greens. In the North the seed is sown early in the spring. The crop grows best on well-drained, warm, and rich soil. As the entire plant is cut and used, some of the thinning necessary may be done by removing the largest plants rather early. If not used, the plants soon run to seed, especially in hot weather. For a late crop sow seed late in summer in the North, and later southward. In the more southern of the planting zones, the plant makes an excellent winter crop.

Peppergrass. The " peppery " flavor of peppergrass or garden cress makes the plant useful in flavoring salads or sandwiches. Its finely cut and attractive leaves are used for decorating (garnishing) various cooked dishes quite as parsley is used. The seed is sown early in spring in shallow drills about 8 inches apart, and the entire plant is cut when it is still tender.

Mustard. For spring crops of mustard, begin sowing seed as soon as the soil can be worked. Plant rather closely in drills about 6 inches apart. In 20 to 30 days begin thinning by cutting out the larger plants, and continue this until plants are ready to bloom. For autumn crops begin sowing seed in late summer, and allow the latest sowing about 30 days for growth before frost. An early crop can be forced in flats and the plants sheared off as needed. The varieties of white mustard having curled leaves, such as *Large-leaved Curled* and *Giant Ostrich Plume*, are recommended.

Nasturtium. This familiar plant of the flower garden can be used as food in the same ways as mustard and peppergrass. The young plants are used entire, or the leaves and flowers of older plants are plucked. These give a delightfully appetizing flavor to mixtures of salads, and especially to cold potato salad. The seed pods of the nasturtium are also of use in seasoning pickles and as a substitute for capers. Sow seeds of the nasturtium about ½ inch deep, rather thickly, in flower beds or in rows in the vegetable garden. Thin by pulling for use the young plants.

From the many leafy crops that may be grown in the home garden, one may select a number that are suitable

FIG. 142. A group of plants belonging to the cabbage family. The varieties shown here all mature at different times. Thus a continuous yield of leafy vegetables may be had from this little plot from early summer until winter. *a*, Early Wakefield cabbage; *b*, late head cabbage; *c*, Savoy cabbage; *d*, Brussels sprouts; *e*, cauliflower. A little planning will enable the gardener to have a continuous supply of many different combinations of leafy vegetables.

to almost any condition, locality, or family taste. Rhubarb, bulblet onions, Swiss chard, New Zealand spinach, leaf lettuce, cabbage, pe-tsai (as an autumn crop), and chicory are all easily grown. With experience one can learn to grow many of the other sorts of more difficult culture; that is, if they are at all suited to the local conditions.

A few feet of row for each sort, properly cared for, will provide leafy food of a variety of uses and tastes, fresh out of the garden from early spring until late autumn; the surplus from such crops as late cabbage, pe-tsai, and endive may be stored for winter use, while the crop of chicory may be forced throughout the winter months. The leafy vegetables, so necessary to health, may therefore be had from the home garden in quality, variety, and quantity sufficient for the needs of the family.

Questions

In general, what conditions are best for the development of leafy crops? What conditions are unfavorable? Why are most leafy vegetables best when fresh? What leafy crops are propagated vegetatively? Which of these are hardy perennials? Describe the propagation and culture of rhubarb.

What are onion sets? How are they obtained from seed onions? What are the advantages of planting onion sets? the disadvantages? What are the important points to remember in onion culture? When should onion bulbs be pulled? What is meant by "cut-and-come-again" vegetables? What are the general requirements for this class of leafy vegetables? How is Swiss chard grown? Describe the culture of New Zealand spinach.

Describe the general method of growing and storing endive. How is Witloof chicory (French endive) grown to produce salad crops for winter use?

What leafy crops are grown by the transplanting method? How is celery grown? Describe the various methods of blanching celery. Which is the most practical of these? Tell how you would proceed to raise a crop of late cabbages in the Northern states; in the Southern states. What special conditions do Brussels sprouts require? Describe pe-tsai. What special attention does head lettuce require? What leafy crops are grown from seed planted directly in the garden? Why is thinning especially necessary for these crops?

Things to Do and Observe

1. *To determine the best leafy crops for your locality.* Find out which leafy crops are generally grown in your vicinity. Inquire especially if pe-tsai and French endive are being raised.

2. *To learn the best ways of growing leafy crops.* Talk with other gardeners in your neighborhood about the proper methods of growing leafy crops. Compare the results of their methods with yours. Which method proved to be the most successful? If the methods were the same and results different, try to determine the cause of the difference.

CHAPTER SIXTEEN

GARDEN CROPS GROWN FOR THEIR FRUITS

> Seeds are the cradles of plant babies; fruits are the houses in which the cradles are placed. And the gardener, devouring houses, babies, and cradles together, smacks his lips and exclaims about the quality of his vegetables!
>
> NEVIN WOODSIDE

THE various garden crops grown for their fruits may be grouped as follows:

A. Cool-season short-period crops —
   (1) Garden peas.

B. Warm-season crops, the seeds of which are sown directly in the garden —
   (1) Beans.
   (2) The vine crops.
   (3) Okra.
   (4) Sweet corn.

C. Warm-season long-period crops requiring transplanting —
   (1) Tomatoes.
   (2) Peppers.
   (3) Eggplants.

This list is not long, but it includes several of the most important garden crops, among them peas, beans, corn, and tomatoes. Since it is the fruit of these crops that is eaten, they are grown until the plants approach full maturity; yet in most cases the fleshy fruits are used while green or immature, and before the seeds are fully ripe. With the exception of garden peas, all the crops here listed are tender, warm-season plants, strongly affected by even slight frosts.

Because of the great difference in the habit of growth of the different plants, requirements for culture differ greatly.

GARDEN PEAS

The common garden peas are divided into two main sorts — *smooth-seeded* and *wrinkled*. The smooth-seeded varieties will begin growth in rather cold soil, and are not injured by light frosts. They are therefore best for planting as soon as the soil can be worked in spring. They mature rather quickly, and are in most sections short or dwarf in habit and hence need no support to hold the plants erect. *Alaska* is a standard variety of this class.

The wrinkled-seeded varieties are sweeter but less hardy, and must be planted later in the spring. There are both low-growing and tall-growing varieties of wrinkled peas. Some of the dwarf sorts, as *Little Gem* and *American Wonder*, are extra early in developing. *Gradus* (also called *Prosperity*) grows to a height of about 3 feet and is one of the best sorts. The tall-growing varieties require a longer period for growth and should have a support of brush or a trellis, made with poultry fencing or otherwise, upon which the plants are held erect. *Telephone*, *Prize Taker*, and *Champion of England* are excellent sorts.

All varieties of peas require cool weather for proper growth. If the pods do not mature before extremely hot weather, they will invariably be few and will be poorly filled with seeds.

The best crops of peas are grown on rich, well-drained

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FIG. 143. Kidney beans will grow in almost any soil and are one of the best crops for a beginner to raise. This garden was planted chiefly to bush beans, with climbing beans along the fence. Strings were run from the ground to the top of the fence to support the vines until they reached the top.

soil. In such soil sow the seed in a trench about 4 inches deep and cover with 2 inches of soil. Then as the plants grow, fill in the trench until it is level with the surrounding surface. The seeds are sown about 2 inches in the row. For the dwarf sorts the rows may be about 2 feet apart; the tall-growing varieties require more room. On soil that is likely to be wet during the early springtime, peas are planted on slight ridges and covered to a depth of about an inch only.

The marrowfat peas are of somewhat more vigorous growth and are more productive than the garden peas, but are of decidedly poorer flavor and quality and are not to be recommended for the home vegetable garden.

The edible-podded or sugar peas are sorts whose entire pods may be used as food when the seeds are about half grown. These require the same cultural treatment as the garden peas.

BEANS

Kidney beans are grown in the garden almost solely for the edible pods and immature seeds, which are known as "string" or "snap" beans. Lima beans have much larger seeds, and are grown for the shelled beans. There are dwarf or bush varieties and running or pole varieties of both kidney and Lima beans.

Fig. 144. String beans that become too old to be eaten in the pod can be used as "shell beans."

All varieties of beans are tender and are planted after danger of frost is past. String beans thrive best on rich soil. They will grow on any soil, however, and on raw or newly cultivated land often give better returns than most other garden vegetables. Lima beans are more difficult to grow. They require a richer soil, more warmth, and have a longer growing period.

FIG. 145. The Kentucky Wonder bean yields abundantly, it is excellent in quality, either as pod or shell beans, and the ripened beans may be used for baking.

Kidney or string beans. According to the color of the immature pods, string beans are divided into the *green-podded* and the *wax-podded* sorts. There are dwarf and pole varieties of each sort, and some varieties are more nearly stringless than others. The beginner should plant such standard kinds of the bush varieties as *Stringless Green Pod*, *Improved Golden Wax*, and *1000 to 1* (also called *Late Refugee*); and for a pole variety, he may well plant *Kentucky Wonder*. The *Tennessee Green Pod* is a bush variety that is said to excel all other string beans in flavor.

As the seeds of kidney beans become larger and more mature, the pod portion becomes thinner, less juicy, and drier. While the seeds are still soft, they may be shelled and cooked as "green shelled beans." When cooked with kernels of sweet corn cut from the cob, they make the well-known dish called "succotash." If the seeds ripen fully, they may be used as "dry beans," but dry beans can be bought in the market much cheaper than they can be produced in the home garden.

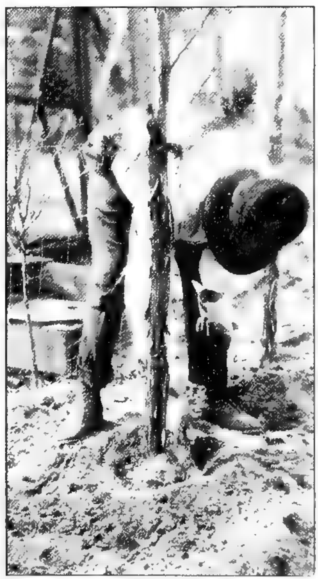
Edible pods will be produced by some of the bush varieties in about 30 days after date of planting. Plant for successive crops at intervals of about 2 weeks until within 40 days of the probable date of the first killing frost of autumn.

The bush varieties are usually grown in hills with 3 to 5 plants in a hill, and the hills about 12 to 15 inches apart. In a small garden the rows may be 2 feet apart. The bush varieties are the easier to grow. All kidney beans may be planted as soon as danger of frost is past.

Pole varieties bear longer and somewhat more abundantly. There are numerous good varieties, but *Kentucky Wonder* is perhaps the favorite. The vines should be supported on poles or by a trellis or fence.

Lima beans. The dwarf varieties are easiest to grow in the home garden, as they need less space and require no support. These may be planted in hills, or in continuous rows like the dwarf varieties of kidney beans.

Pole Limas are usually grown in hills. Remove the soil to the depth of about 8 inches and a diameter of 10 inches, place two shovelfuls of well-rotted manure in the hole, cover with soil, and plant 5 or 6 seeds 1½ inches below the surface, placing the seeds on edge with the "eye" down. The hills should stand about 3 or 4 feet apart. Supports should be set in the ground at the time the hills are prepared. A stout pole may be placed in the ground in the middle of each hill, or lighter poles or laths may be used. When the lighter supports are used, it is a good plan to lean together those from three or four adjacent hills of two rows, tying them together securely at the top. The giant-podded sorts of pole Limas are somewhat more difficult to grow than the small-seeded pole Limas. The *Sieva* or *Carolina*, well known in the South as the "butter bean," is one of the best of the small-seeded sorts.



FIGS. 146 and 147. Planting Lima beans. This crop is more difficult to grow than the kidney bean. It will not be a success unless the soil is rich and well prepared, the seed planted at just the right time and depth, and the plants well cared for through the entire season.

VINE CROPS

All the vine crops grown for their fruits belong to the *gourd* family. They are very much alike in habit of growth and in cultural needs. All are tender and decidedly warm-season crops, maturing in summer or autumn. Their wide-spreading vines require more room than can usually be spared in the garden of small size. In the more northern states the season of growth is scarcely long enough for some of the vine crops to mature.

Of this group, the bush squashes and the cucumbers are the most suitable for planting in the home garden. The bush "squashes" (really pumpkins) do not have the vine habit, and their fruits mature in summer.

All vine crops are grown in hills. For early crops, plants may be started under glass, but special precautions should be taken to keep the roots intact during the transplanting. As seedlings of these plants develop quickly, they should be started only about 2 weeks before the planting date.

Cucumbers. In the home garden cucumbers are grown chiefly for the green, immature fruits. Grow in hills about 4 feet apart in rich soil and keep well watered. In the cooler sections of the more northern states a single planting of both early and later varieties may be sufficient. Further south and in sections where the summers are hot and dry the plants tend to die during the summer, and a second or late planting is advisable. Cucumbers may be grown as a companion and follow crop with such early crops as radishes and peas.

The *White Spine*, *Davis Perfect*, and *Emerald* are all recommended for culture throughout the United States.

Pumpkins and squashes. Many of the plants commonly called "squashes" are really more closely related to the pumpkins than to the true squashes. The best of these for home gardens are the *Yellow Crookneck*, very generally known in the North, and the *Scallop* and the *Patty Pan* types, more generally grown in the South. These are bush varieties that take up little space. The fruits are used while still green and before the shells become hard.

A recent variety, the *Fordhook*, which appears to be suitable both for summer use and for winter storage, is worthy of a trial.

The *Vegetable Marrow*, with a running vine habit of growth, is also a pumpkin. It is a favorite in England and seems to deserve more general use in America. The *Improved Prolific Marrow* is early, an abundant yielder, and excellent for frying when the fruits are yet small.

The large-fruited pumpkin is a well-known field crop often grown as a companion crop with corn. Varieties known as "sugar pumpkins," which have smaller fruits that mature earlier in autumn, are more desirable for the home garden.

The best known of the true squashes is the *Hubbard* or winter squash. This plant has a wide-running vine, and it requires plenty of sunlight. Its large, hard-shelled fruits mature in autumn and are stored for winter use. The *Delicious* is said to be the best flavored of the winter sorts, and when partly mature its fruits may be used in the same way as those of the summer squashes.

FIG. 148. Vine crops may be grown along the edge of a planting of corn, or alternately with double rows of corn. The vines are then allowed to run in among the corn, and where the summers are hot the crop is often better because of the partial shade from the corn. The photograph shows pumpkins and corn as close neighbors.

The *Cushaw*, also known as the *China* or *Canada Crookneck* and as the *Winter Crookneck*, is sometimes classed with the pumpkins and sometimes with the squashes. It is really a different species. The Cushaw produces a fruit having a long, thick neck of solid flesh; all the seeds are in a small cavity in the outer end, which is somewhat enlarged. The variety *Japanese* is the earliest, and *White Cushaw* is a well-known winter sort.

Squashes and pumpkins respond well to the addition of manure in the hill, as described on page 263 under directions for planting Lima beans. The pumpkin with running vine and the Hubbard squashes may be grown as a companion crop with corn.

Melons. Muskmelons (including cantaloupes) and watermelons are grown in the same manner as cucumbers.

FIGS. 149 and 150. Muskmelons. The young plants at the left are being given an early start in glass-covered individual frames. At the right flower pots are being placed under the melons to raise them off the ground. This prevents rotting and insures more even and quicker ripening.

They thrive much better, however, during hot weather, for the heat and light of summer are necessary for the maturing of the fruits. A rich, well-drained soil will often produce good melons, but as a rule the conditions in most home gardens do not make a good crop certain. Muskmelons should be grown in hills spaced about 6 feet apart; watermelons require more space.

The juice of the preserving watermelon, commonly called *citron*, is used in making jelly of fruits whose juices do not readily jell alone. The flesh is used in making preserves.

Seed catalogues list many varieties of muskmelons. The beginner should perhaps choose first the sorts that are most successfully grown in the locality. The *Rocky Ford* or *Netted Gem*, *Emerald Gem*, and *Defender* (also called *Burrel's Gem*) are excellent sorts for general culture. *Extra Early Hackensack* and *Osage* are two other varieties that are extensively grown.

OKRA

This plant grows splendidly throughout the southern and the middle states. Dwarf varieties can be grown with some success farther north, especially if seedlings are started under glass; and in some sections of the North the crop grows well if planted on rich soil in a sunny location.

The crop thrives on any good garden soil, but does best on a rich, well-drained soil. The seed is slow in germinating, but the process can be hastened and made more certain by soaking the seed in water. Because of the cold soil, the seed of early plantings often fails to germinate.

The seed is sown in rows rather thickly, to allow for poor germination. The plants that grow should be thinned to stand 15 to 18 inches apart in the row. The young tender pods are harvested when one-half or two-thirds grown, and used in soups, as well as for making the famous Southern "Creole gumbo."

The *Dwarf Prolific* is an early variety that can be recommended. Other excellent sorts, such as *White Velvet* and *Long Green*, are very satisfactory.

SWEET CORN

This plant should have a place in every garden, except perhaps those of very small area. It is easily grown, its fruit has a high food value, and any surplus in the crop can readily be canned or dried. Besides, some of the most delicious varieties, such as the *Golden Bantam*, can seldom be bought in the markets. This variety is undoubtedly the best for the home garden. It does not yield so heavily as larger-eared sorts, but it is more sweet and tender.

An excellent plan is to grow about three varieties which mature at different times. A judicious planting of early, medium, and late sorts, to the total of 100 hills or more, will supply the ordinary family abundantly.

The first planting of corn is made after all danger of frost is past. Plant the seed from 1 to 2 inches deep, either in rows or in hills. If in rows, the single stalks may stand about 12 to 15 inches apart; if in hills, plan for 3 stalks in a hill, with the hills 3 feet apart each way.

Succession plantings of one variety may be made at intervals of 2 weeks; but if the soil is not especially rich and well watered during a dry summer, this plan may result in a stunted development of the later crops. As a rule, the more certain plan is that of growing early and late varieties which are planted about the same time.

The ears are best for table use if picked in the "milk stage" and used promptly. In the milk stage the kernels are well filled and plump, but still soft and juicy. They are right for use when a quick, sharp pressure of the finger nail causes the seed coat to burst and the juicy

FIG. 151. "But let the good old crop adorn
The hills our fathers trod;
Still let us for His golden corn
Send up our thanks to God." WHITTIER

milk to spurt out. The seeds soon pass to the " dough stage " ; the contents then become somewhat like dough or putty.

The seed catalogues offer a choice of many varieties of sweet corn. Extra early varieties to be recommended are *Golden Bantam*, *Malcolm*, and *Nordheim Extra-early;* medium early varieties are *Adams' Early* and *Crosby;* the best of the late sorts are *Country Gentleman*, *Black Mexican*, and *Stowell's Evergreen.*

Pop corn is grown in the same way as sweet corn. The ears should fully ripen on the stalk and should be stored where they are neither too damp nor too dry.

FIGS. 152 and 153. At the left, cutting the "suckers" from the corn; at the right, training up a tomato vine by the stake method.

FIG. 154. Tomato vines with barrel-hoop supports.

Varieties like *Tom Thumb* and *White Rice* may be grown in the home garden.

TOMATOES

From 80 to 125 days are needed to bring the fruits of the tomato to ripeness. To secure early crops, it is necessary to have plants of good size ready for transplanting to the garden as soon as danger of frost is past. With proper care such plants can be had in from 6 to 8 weeks from time of sowing seed.

The tomato is a tender plant that quickly suffers from poor treatment, but it responds to careful handling and proper transplanting. There are many good varieties of tomatoes. For general table use those with medium-sized, well-formed, solid, red fruits are most desirable.

In the North the early and late varieties are planted at the same time. In the South, where the plants grow


FIGS. 155 and 156. At the left, setting out pot-grown peppers; at the right, harvesting the "eggs" from eggplants.

poorly or may even die during the summer, a late crop may be raised.

In the home garden it is best to grow plants from 18 to 30 inches apart. Each plant should be tied up to one or more stakes as a support, and the side branches cut away as they develop, leaving the main stem and possibly two or three lateral ones to develop. After several clusters of fruit are formed on a stalk, it is a good plan to pinch off the growing tip.

Earliana, *Bonny Best*, and *Chalk's Early Jewel* are perhaps the best of the early sorts. The *Stone*, *Acme*, and *Ponderosa* are somewhat later, but yield heavily.

PEPPERS

Peppers are tender plants requiring quite the same temperature conditions as the tomato. They are slower in growth and need a longer growing period. In the northern states only one crop can be grown, and this by the transplanting method. A few plants will usually supply the needs of a family; the plants may stand from 1 to 2 feet apart in rows. The large-fruited and sweet varieties are best. The smaller sorts are more "peppery" in taste.

EGGPLANTS

The eggplant needs a rich, warm soil, for it is a tender plant and grows slowly. A period of 8 or 9 weeks of proper forcing under glass is necessary to bring the plants to good size for transplanting to the garden. The beginner is advised to try one of the early small-fruited sorts and to rear or purchase well-grown plants for planting. Fortunately the fleshy and almost solid fruits are used before they are fully ripe, and for this reason the crop may be grown where the season is too short to bring the fruits to full maturity. In the extreme North, however, the growing season is rather too short to bring the plants to full production.

Questions

What are the main differences between the smooth-seeded varieties and the wrinkled varieties of garden peas? How should peas be planted? How do string beans and Lima beans differ in their requirements? Describe the proper method of planting Lima beans.

What can you say of the general characteristics and cultural needs of the vine crops? How should cucumbers be grown? Name some of the pumpkins and squashes and their individual characteristics. What special conditions do melons need to grow and yield well? How is okra grown?

When should the first planting of corn be made? How is it planted? What is the best plan for providing a successive yield of corn? What is the best way of determining when the ears are best for table use? Why should sweet corn be used as soon as possible after it has been pulled?

How much time does the tomato plant need to grow from planting the seed to yielding the first fruit? Describe the planting and care of tomatoes. Give a brief summary of the cultural requirements of peppers; of eggplants.

Things to Do and Observe

1. *To determine the varieties of the crops that are grown for fruits in your neighborhood.* Visit every garden in your neighborhood. Make a list of each variety of fruit crop grown in gardens, and put down the number of gardeners growing each variety. Then find the variety that is grown by the greatest number. Ask each gardener why he grows this particular variety. For example, if you find that of the pole beans Kentucky Wonder is the variety most often grown, find out from each grower if he grows this variety because he likes the flavor, because it yields abundantly, because it is easier to grow than others, or just because other gardeners in his neighborhood grow it.

2. *To find the best method of bringing tomatoes, melons, and squashes to early fruiting.* Inquire of gardeners if they use plant protectors in the spring and if they have any special practices for causing these plants to fruit early.

CHAPTER SEVENTEEN

GARDEN PLANTS GROWN FOR THEIR STEMS

Leaves for relishes! But for solid support, let us have the stems.

NEVIN WOODSIDE

IN the United States, Irish potatoes, the Jerusalem artichoke, kohl-rabi, and asparagus are the only important garden vegetables that are grown for their stems. These four plants belong to widely different families of flowering plants, and are very different in their cultural needs.

THE IRISH POTATO

The underground tubers, or thick, fleshy stems, of the potato have recently become a most important food for man. The plant is a native of America, but it is now cultivated over practically all the cooler parts of the world and also in the mountains of the tropics. More tons of potatoes than of either wheat or rice are now used each year for human food; so the potato is one of the leading food plants of the world.

In general, potatoes are a field rather than a garden crop. On the farm there is every advantage in growing them in fields where rotation of crops is the rule. The villager and others who own at least a half an acre or more of land may find it profitable to raise potatoes, especially the early sorts which mature at the time potatoes command the highest prices. In the small garden, where intensive methods are necessary and a crop must be judged by the returns for the space it occupies, the potato is not as profitable as some other crops. Another reason for buying potatoes, rather than raising them in a

FIG. 157. Planting potatoes. The tubers are never formed deeper than the "seed" is planted. Hence the planting furrow should be 3 or 4 inches in depth.

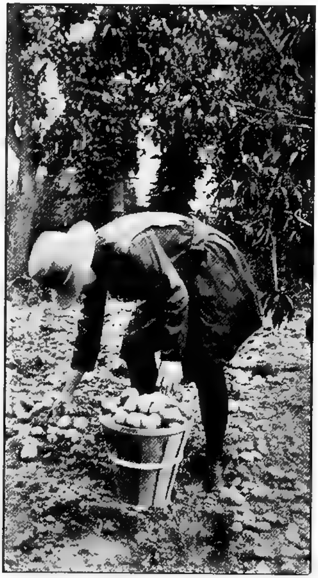
small garden, is that they stand shipping well and those bought are often of better quality than those grown at home.

The plant is propagated from the tubers, which are cut into three or four pieces of nearly equal size so that each piece has at least two "eyes" or buds. These pieces are planted from 3 to 4 inches deep and 12 to 15 inches apart in rows that are $2\frac{1}{2}$ or 3 feet apart. Cultivate well, and hill up the soil about plants to protect the tubers from the sun and to give loose earth in which they can develop.

In the North the early crop is planted as soon as the soil can be prepared in spring, and tubers for the main and late crop are planted soon after. In the South the early crop is planted from December to March, according to the winter conditions prevailing in the particular section.

A fall crop is planted in July or August. There are many varieties of both early and late sorts, and as a rule the same variety is not planted for both the early and the late crops. It is best to grow the kinds most generally cultivated in the region.

Potatoes are very subject to attacks of many diseases. Some of these diseases are carried from year to year in the tubers. Such diseases may be avoided in a large measure by planting tubers from crops grown in northern Maine, Vermont, New York, or Wisconsin, where these particular diseases are not so frequent or so severe. Other diseases, commonly called " blights " and " rots,"



FIGS. 158 and 159. At the left, dusting with Paris green; at the right, gathering the crop.

may be kept somewhat in control by spraying with Bordeaux mixture (see page 295).

Insect enemies of potato plants are always abundant. In some years the potato aphid (a tiny plant louse) is very destructive unless vigorously combated with nicotine sulfate sprays. The potato " bug " (really a beetle, not a true bug) is nearly always present. Dusting with Paris green and the use of poison sprays are effective for the larvæ of potato beetles, and the adults can be eradicated by hand picking.

JERUSALEM ARTICHOKE OR GIRASOLE

This sunflower was a food plant well known to the

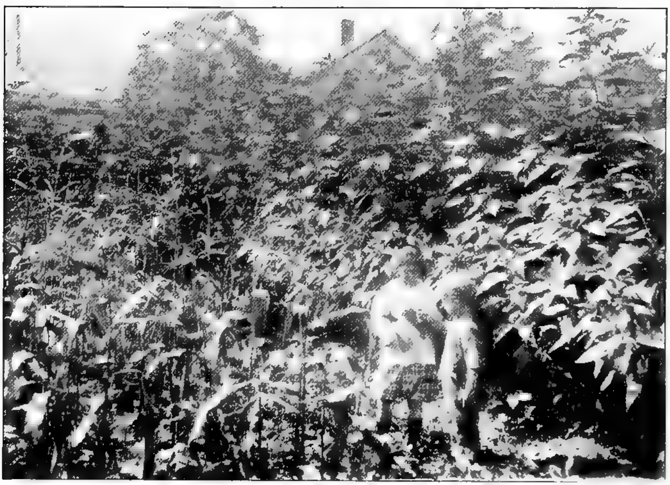


Fig. 160. The Jerusalem artichoke is ornamental as well as useful. Here it is grown on the edge of the garden to serve as a screen for the hen yard in the rear.

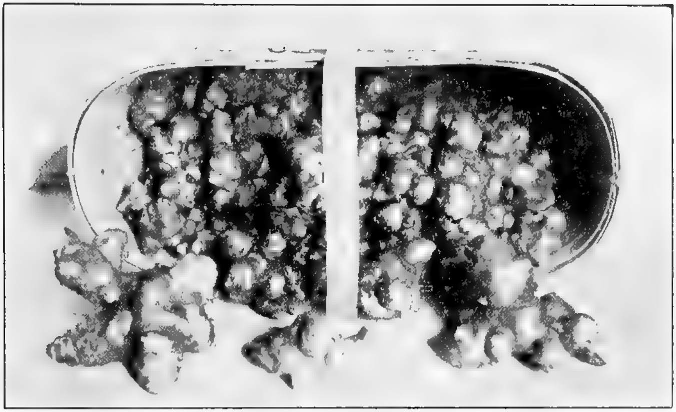


Fig. 161. Tubers of Jerusalem artichoke, all from one hill.

Indians at the time America was discovered. It was soon taken to Europe, where it has been rather extensively cultivated; but in its native land it has been neglected. The swollen underground stems are delicious; they are usually served boiled.

The girasole thrives in any good garden soil. Plant three or four small tubers or pieces of large tubers in hills 3 feet apart each way. Cultivate as for corn. The leafy stems grow to a height of 6 or more feet, making a dense mass of foliage. The yield of the improved sorts is truly enormous; a single hill of the "white-tubered" variety often yields as much as 18 pounds of tubers. Some of the less prolific sorts, as *Sutton's Rose*, have smoother tubers than those that yield more abundantly.

The tubers are ready for use in October; and as the plant is hardy, they may be left in the ground during the winter without injury.

FIG. 162. Cutting asparagus. The stalk should be cut an inch or two below the surface of the soil.

As the plant often grows to a height of 8 or 10 feet, it is especially effective as a hedge-like screen (Fig. 160).

ASPARAGUS

This hardy perennial survives severe winter weather and yields crops of fleshy young stems very early in the spring. The plant will thrive on any good garden soil, but prefers a rich, sandy loam. The site chosen for an asparagus bed should be well drained and so situated that it dries out quickly in the early spring.

Before the plants are set out, the soil should be spaded deeply and abundantly manured. For the garden it is best to buy well-grown roots one year old. Plant either in autumn or in spring, rather deeply (4 inches beneath the surface), 15 inches apart in rows 3 feet apart. Make a trench or furrow 4 inches deep and set the plants in the bottom, spreading the roots out horizontally in all directions. The crown of the plant is thus buried deeply, and is less likely to be injured when the stalks are cut for table use. During the first year after planting, cut none of the young shoots for table use; and cut

Van Evrie Kilpatrick

Fig. 163. Kohl-rabi is in the best condition for use when about the size shown in this picture.

sparingly the second year. In spring cultivate freely between the rows and pull loose soil up, forming a ridge over the row. This helps to blanch the shoots as they push up to the light.

The cutting season lasts for several weeks, but toward its close the shoots become smaller and more woody. Then it is time to level the ridges with a rake, working into the soil at the same time a liberal coating of well-rotted stable manure. The green branches are now allowed to grow throughout the rest of the season and thus store up food in the roots for the crop of the following spring.

With proper care a bed will remain highly productive for as long as 15 or 20 years. If a bed is producing only poor, spindling shoots, it is best to start a new bed elsewhere, using new plants.

KOHL-RABI

Kohl-rabi is a member of the cabbage group that produces a fleshy enlargement of the stem just above the ground. If gathered before it reaches full size (about

2 or 3 inches in diameter), this stem portion is tender and juicy, and when cooked like turnips it is of excellent flavor.

In the extreme north of the United States, seed sown directly in the garden about May 1 will begin to yield a crop about July 1. Well-grown plants transplanted to the garden on this date (May 1) will mature somewhat sooner. In the South, very early and late crops may be treated the same as early and late crops of cabbage. Late crops may be stored for winter use, along with cabbage and root crops. Plants maturing in warm weather soon become pithy and tough if not used; hence kohl-rabi should not be overplanted. In localities with cool, moist summers, the crop does excellently during summer; but in sections with hot, dry summers, it often fails if planted so that it matures during the hot weather.

The variety *Early White Vienna* is recommended for general use.

Questions

Why is the potato an important vegetable? Why are potatoes a field rather than a garden crop? How are they planted? When is the usual time for planting them? What does "hilling" do for potato plants? How are potato beetles controlled?

How should Jerusalem artichoke be grown? What would be the best place in the garden to plant it?

Describe the method of starting an asparagus bed. How should the bed be treated after the cutting season? How long should a good asparagus bed last? What are the indications that a bed is not doing as well as it should?

How does kohl-rabi differ from head cabbages? How is this plant affected by hot weather?

Things to Do and Observe

1. *To determine the best kind of soil for potatoes.* By inquiry and observation learn the kinds of soil in which potatoes are grown in your neighborhood. If you find that some are grown in different soils, find out which gives the biggest yield. If potatoes are not grown at all in your locality, find the reason why.

2. *To determine what vegetables may be grown successfully as border plants.* In your visits to gardens note what vegetables are used as border plants; that is, what vegetables are planted outside the main gardening area. For example, in one garden you may find a double row of asparagus along the fence. This arrangement does not interfere with the cultivation of the garden, and the plants form a pleasing background. What other plants do you find grown in this way?

3. *To determine the best time to plant the various crops.* Talk with gardeners about the best time to plant each crop. Take special note of what the older, more experienced gardeners tell you. If you find that some go by the condition of the trees, shrubs or flowers, make notes of the information given you.

CHAPTER EIGHTEEN

DISEASES OF PLANTS

> As a Blight is the most common and dangerous Distemper that Plants are subject to, so I shall endeavour to explain by what Means Vegetables are affected by it; and if I shall be so happy, from the Observations I have made, to discover the Cause of it, the Remedy may then be more easily found out, and the Gardener will with more certainty hope for Success from his Care and Labour.
>
> *From an Old English Garden Book* (1726)

All the vegetables of the garden are plants that have roots, stems, and leaves. Each of these parts has different work to do; and in the plants there are vessels to carry water, minerals, and foods between the different parts.

The garden plants all have chlorophyll, a green coloring matter which makes them able to use the energy of the sunlight in building food. They are, therefore, self-supporting; they can make their own food from carbon dioxid taken from the air, and from water and minerals taken from the soil. As we have learned in earlier chapters, this is one of the main reasons why they are so valuable to man as food plants.

The garden plants also produce seeds, which usually pass through a resting period before the young plants resume growth. In this way the plants that live but one year are able to pass the winter months.

In all these respects garden plants are like the many kinds of trees, shrubs, and herbs that are abundant and conspicuous all about us. Because of these qualities, and especially because of their power to produce seeds, these plants are considered to be the *higher forms of plant life.*

Lower forms of plant life. But all about us are many sorts of plants that never produce flowers and seeds. The simplest form of these seedless plants have no roots, stems, or leaves. Some are so small that we cannot see them with the naked eye. Many of these seedless plants have no green coloring matter and hence are not able to make their own sugary foods. These colorless (not green) and seedless little plants are all about us, and they affect our crops in so many ways that we need to learn about them.

Plants without green coloring matter. The fungi (singular, fungus) are a great group of colorless and seedless plants. Mushrooms, puffballs, molds, and the bracket fungi (found on trees) are members of this group. Although some are quite large, they are all composed of single filaments of cells or groups of such filaments and have no leaves, stems, roots, or flowers and no special conducting vessels within them. The fungi produce great numbers of small *spores* that, when scattered abroad, start the new plants.

The yeasts and bacteria are other examples of colorless and seedless plants. In these the plant consists of but a single cell. The yeasts multiply by budding; the bacteria, by simple division. Some of the yeasts and bacteria produce spores that can withstand drying and a high temperature without injury. Some vegetables are difficult to can so that they will keep, because they carry bacterial spores that are killed only by steaming under pressure or by a long period of boiling.

Parasites. A colorless plant cannot make its own food, but, like an animal, it must have food that is already prepared. Some of these plants, such as the mushrooms and bread mold, use dead plant or animal material for food. Others feed directly on *living* plants or animals. These are called *parasites*, and the plant or animal on which the parasite feeds is called the *host*.

Parasitic diseases of plants. Many diseases of garden plants are due to the attacks of parasitic plants such as the rusts, smuts, and mildews. Most blights and rots are caused by fungi; but some of them, and also many other plant diseases, are due to bacteria.

It is only within the last forty or fifty years that the cause of these diseases has ceased to be a mystery. The host plants become sickly, and even die suddenly; but because of their small size, the parasites are not even seen with the naked eye. But the invention of the microscope enabled man to see these small parasitic plants; consequently much is now known of the various parasites that cause plant diseases and how to control them.

The gardener can learn to recognize many of these diseases by such signs as spots or blotches on the leaves, by the occurrence of powdery or moldy growth, or by the decay or rotting of parts. Just as the physician, without seeing the germs, recognizes whooping cough or measles from the symptoms of the patient, so the gardener can learn to recognize plant diseases by the condition of the host plants.

The diseases discussed below are selected to illustrate the various sorts of parasites that are likely to appear on crops in the home vegetable garden, and to give also a knowledge of the diseases that are most destructive to

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FIG. 164. Cabbage plants badly infected with the clubroot disease.

such crops and of the various means that are employed in combating them.

CLUBROOT OF CABBAGE

All the members of the cabbage group, as well as turnips, radishes, rutabagas, and mustards, serve as the hosts of a parasite which causes a disease known as *club-root.* This disease is especially common in cabbage over most of the United States east of the Mississippi River. Young plants are often attacked in the seed bed. They become stunted and sickly and seldom grow to maturity. They wilt during the heat of the day. The roots soon become greatly swollen and misshapen. This condition leads the gardener to speak of the disease as the clubroot; but it is also known as "clubfoot" or the "finger and toe" disease.

The fungus causing this disease lives, during one stage of its life, in the soil. It enters the roots of its host, and multiplies by a simple kind of budding process. After a period of feeding, during which the host becomes greatly weakened, many spores are produced by the fungus within the roots. Later, when the roots of the dead host decay, these spores become mingled with the soil. Under proper conditions, which usually occur during early spring, they germinate and infest plants of the new crop.

Means of control. All diseased plants should be dug up and burned, care being taken to get all the roots out of the soil. If the disease appears in cold frames or hotbeds, one must remove and discard all the soil, and thoroughly clean out flats and frames before using for another year. The destruction of diseased plants and the cleaning of frames is one of the first remedies to use in preventing the disease.

A second method of combating the disease is to plant in the infected soil crops not attacked by it. *Do not grow cabbage on ground where cabbage was attacked the previous year, and do not use soil from infected areas to grow seedlings of cabbage.* If the disease appears in an early crop, do not plant a late crop of cabbage in the same earth, but use this space for late crops of some vegetable that is not subject to the disease, such as endive or celery.

As the fungus thrives best in an acid soil, the application of lime to the land helps in controlling the disease.

The root-knot disease, which is caused by small "eel-worms," may be confused with the clubroot disease, in the southern states especially. The worms infest the roots and produce swellings, but these are smaller than the swellings of the clubroot. By breaking open the swollen roots, one may often detect pearly white bodies about the size of a pin head; these are the female eelworms.

To combat this animal parasite, practice crop rotation, destroy all diseased plants, and clean the frames and flats, as is recommended for the clubroot.

BACTERIAL WILT OF VINE CROPS

This disease is caused by a bacterium that lives within the woody vessels which carry sap up to the leaves. This parasite is so minute that many thousands of them can live together within a single cell of the host plant. In time, the vessels are broken down and cavities formed within the host. The supply of water is thus checked, and the plant suddenly wilts and soon dies. There is no recovery and no cure for plants after the germs once get inside.

The minute germs of this disease are carried from diseased plants to healthy ones by the striped cucumber beetle. This insect chews into diseased plants and gets the bacteria on its mouth parts; then when it chews into healthy plants, the bacteria gain an entrance.

The best measures of prevention are: (1) to destroy and combat the striped beetle, and (2) to burn all plants as soon as they become infected.

The various vine crops also wilt suddenly and die when attacked by the grub of the stalk borer, but in this case proper examination will reveal the grubs burrowing in the stem near the base of the plant (page 333).

Plants may also wilt badly from lack of water. One needs to recognize the various conditions that cause wilting before deciding that the bacterial wilt is present.

Muskmelons, watermelons, cucumbers, and squashes are all subject to attacks of this disease at any time during their growth. It is now a common and a very serious disease of vine crops in the United States.

OTHER BACTERIAL DISEASES OF GARDEN CROPS

A wilt disease of potatoes, tomatoes, and eggplants caused by a bacterium is especially destructive in the southern states.

A soft rot of the carrot and other vegetables is a common and widespread disease and is caused by another bacterium.

A bean blight, caused by a bacterium, is common on both the kidney and the Lima bean. Its presence is readily detected by the occurrence of water-soaked patches or swellings that appear in the stems, leaves, and green pods. The disease is seed-borne and there is no effective control, except the use of seed from healthy plants. However, treatment of diseased seed is somewhat effective in preventing this disease.

Before planting, soak the seed in a solution of mercuric bichlorid (1 part to 1000 parts of water) for 15 minutes; then rinse or wash in pure water, after which spread out the seeds to dry. This kills the bacteria that are being carried on the seeds. As the solution attacks metal vessels, an earthenware dish should be used. *Mercuric bichlorid is a deadly poison and should not be used by children.*

A " black rot " of cabbage (also called " brown rot," " stem rot," and " dry rot ") is caused by a bacterium. Young plants are killed; older ones lose their leaves and become rotted. As young plants may become infected in flats or in seed beds, these should be watched. Any plants showing signs of the black rot should be destroyed. The disease is seed-borne; hence it is advisable always to disinfect seeds of cabbage with mercuric bichlorid as directed above for destroying the germs of bean blight.

All the diseases mentioned above are combated by destroying diseased plants, by keeping flats and frames clean, and by crop rotation.

THE DOWNY MILDEW OF THE CUCUMBER

Through the eastern and the southern states the downy mildew is a very destructive disease of the cucumber and of all the vine crops related to it. The first sign of attack is the appearance of yellowish spots on the leaves. These rapidly enlarge until the leaves are almost or entirely yellow or brown, when they soon die. The older leaves are attacked first, and the disease progresses toward the tips of the vines until the plants are either killed or very much stunted.

The disease is due to a fungus, which cannot itself be detected with the naked eye. But an examination of the discolored areas under a microscope will reveal colorless, branched, and thread-like stalks of the fungus pro-

FIG. 165. Cucumber vines destroyed by bacterial wilt. A week before this picture was taken the vines were growing vigorously.

truding through the breathing pores on the under surfaces of the leaves and extending out into the air. Very small spores are borne on the ends of these branches. When the spores are mature, they readily become separated from the stalk and may be borne long distances by the wind. If, by chance, a spore lodges on a cucumber leaf (or the leaf of a melon or squash), it gives rise to thread-like filaments which may grow through a breathing pore into the interior of a leaf. Here the fungus feeds from the living cells of the host, becomes mature itself, and sends out into the air branches which bear spores for another germination.

The parasite, therefore, lives within the leaf. It is outside on the surface of the plant for only a short time previous to gaining entrance, and also when a part of the fungus is exposed to the air for the short time that the spores are being shed.

Controlling fungous diseases with poison. Poisons which kill fungi are called *fungicides.* The best-known and most valuable fungicide is *Bordeaux mixture.* The standard formula for this fungicide is known as the "4-4-50 formula," so called because it is made from 4 pounds of copper sulfate, 4 pounds of fresh slaked lime (or 5 pounds hydrated lime), and 50 gallons of water.

For the home garden, a smaller amount of the material is usually sufficient for all needs, and it can be made in the same proportions, as follows:

Prepare separately two stock solutions which we will call A and B. To make solution A, inclose 2 pounds of copper sulfate in a cloth bag, and hang it in a vessel containing 2 gallons of water. A metal bucket will be destroyed by the solution; so a wooden or glazed earthenware vessel must be used. The bag containing copper sulfate should be hung in the upper part of the water and not allowed to touch the bottom or sides of the vessel.

To make solution B, prepare a lime paste either by slaking 2 pounds of fresh stone lime in water or by adding $2\frac{2}{3}$ pounds of hydrated lime to water. Then add water to make 2 gallons. This solution also must be made and kept in an earthen or wooden vessel.

These stock solutions may be kept for use throughout the summer, but the vessels should be kept tightly covered to prevent evaporation of water and to keep dust out. As some water will evaporate, it is well to mark the height of the liquid after each use of the stock, and then add water to fill to this height just before the stock is again used. In this way the proper strength of the solution is maintained.

As it is seldom that the home gardener will wish to use more than 3 gallons of spray at one time, this amount can be made up from the stock as follows:

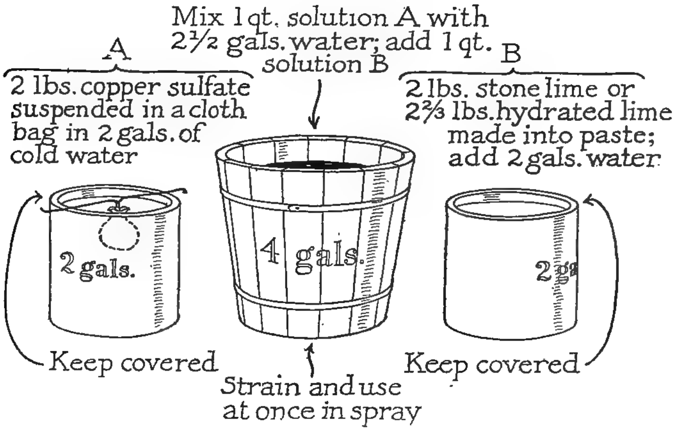

FIG. 166. Diagram showing how Bordeaux mixture is made up.

Stir the stock solutions thoroughly. Place 1 quart of solution A in a wooden pail or glazed earthenware vessel which holds not less than 4 gallons. Add $2\frac{2}{3}$ gallons of water, and mix well.

Next, add 1 quart of stock solution B, and stir thoroughly. Then strain the mixture through cheesecloth into the tank of the spray pump, and use immediately. If a smaller amount of Bordeaux mixture is needed, one-half the amounts mentioned may be mixed for use. Or, if only a very small amount is needed for a single application, it can be made by using 4 ounces of copper sulfate dissolved in 6 quarts of water and 4 ounces quicklime (or $5\frac{1}{2}$ ounces hydrated lime) slaked and then dissolved in 6 quarts of water. When the lime is well dissolved mix the two solutions, strain, and use immediately.

Weaker solutions, such as a 2–4–50 formula, are often prepared for use on young plants and on tender crops that are injured by the stronger solutions.

Sometimes the lime is of poor quality or has lost its strength, or the copper may be so strong that it " burns " leaves that it touches. The solution may be tested as follows: Dip a clean, bright steel knife blade into the prepared solution for 30 seconds. If it is " coppery " in color when removed, there is not enough lime, and lime water should be added until the knife blade does not " copper " when tested.

When this poison is sprayed on the surface of leaves, it kills the germinating spores which

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FIG. 167. The proper way to carry a compressed-air sprayer of the knapsack type. The strap goes over the *left shoulder*, and the tank is partially supported by the *right hand*.

may be present. It will not destroy the fungus after it has gained entrance to the inside of the leaf, however. Spraying with Bordeaux mixture can therefore only prevent the appearance and spread of the disease; it cannot cure diseased plants. Cucumber growers who plant on a large acreage do not wait for the disease caused by downy mildew to appear, but spray about seven times during the growing of the crop. The home gardener should at least begin spraying as soon as he detects signs of disease. If, however, the disease has been present in previous years or is known to be in the locality, it is advisable to begin spraying as soon as the cucumber plants are well above the ground, and to spray thereafter at intervals of about 10 days. If rains occur soon after spraying, much of the poison will be washed from the leaves; it will then be necessary to spray again immediately.

LEAF BLIGHT OR LEAF SPOT OF THE TOMATO

It is estimated by the United States Department of Agriculture that the tomato-leaf blight causes a loss to tomato growers in the United States of at least $5,000,000 each year; yet this loss could largely be prevented if the growers would learn to recognize the symptoms of the disease and to spray properly with Bordeaux mixture.

The fungus which causes this disease attacks the lower leaves first. Small angular or circular spots appear, having grayish or light-colored centers and dark-colored borders. These spots are seldom more than $\frac{1}{8}$ inch in diameter. Leaves thus attacked curl, and then dry and fall. As the disease continues to extend to the newer leaves, the plants may in a short time become almost leafless. In such a condition the plants will produce few or no fruits.

In the center of the discolored spots, small dark dots or pustules may be found. These are cistern-like cavities in which countless spores are produced. Around the spores is a material which when wet becomes jelly-like and swells, pushing the spores in sticky clusters out of the opening of the case. They will cling to insects and to the hands of the gardener, and thus become distributed. Rain may splash spores from leaf to leaf and from plant to plant. Spores which fall to the ground will withstand severe drying for at least three days, during which time they may be blown about with the dust. Many gardeners quite naturally make the mistake of thinking that the disease is caused by wet weather, but the wet weather simply favors the spread of the parasite.

Control of this disease is effected largely by preventive measures. Clean soil should be used in flats and cold frames in which seedlings are started. The spores live over winter on stems and leaves of old plants; hence the dead remains of all tomato plants should be burned in autumn. The spread of the disease can be checked by spraying with Bordeaux mixture (4–4–50 formula) at intervals of about 10 days, or more often during rainy weather. At the first signs of this disease the gardener should tie up plants to stakes, remove and burn the lower and infected leaves which are wilting and showing blotches, and then spray with Bordeaux mixture. All this work, as well as that of cultivation, should be done when the plants are dry.

THE DAMPING-OFF DISEASE

Several kinds of fungi attack young seedlings and cause them to topple over and die. Heavy losses from this cause often occur in seed beds and cold frames. Usually all the plants in an area are attacked and killed, leaving bare patches. In some cases the plants survive until they are placed in the field, but even then they grow poorly and often die.

The fungi which cause damping off can live on decaying organic matter in the soil, they can attack the living tissues of seedlings, and they can continue to feed on the plants after they are dead. Certain of these fungi are practically always present in soil which is rich in organic

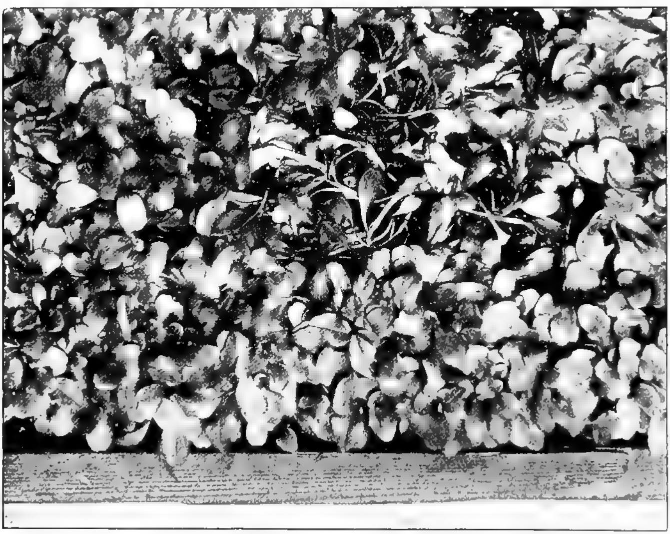

FIG. 168. Lettuce seedlings affected with the damping-off disease. The plants just above the center of the picture are falling down and rotting.

materials. Their growth is favored by an abundance of moisture and warmth.

The prevention of damping off depends largely on the use of proper methods in growing seedlings. Do not use soil so rich that the plants are forced too rapidly. Give the seedlings space, both by proper sowing and by prompt thinning and transplanting. Supply water only according to the needs of the plants; mix sand with the soil to help the drainage; regulate the temperature and ventilate the frames to harden the seedlings. With such precautions, damping off will seldom be serious. If it appears in flats, discard the entire flat and plant new seeds in less rich soil, or select healthy plants from uninfected parts of the flat and transplant them to a new flat with fresh earth less rich in humus.

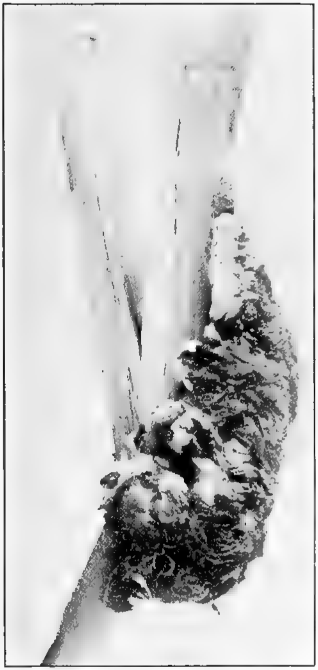

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FIG. 169. Portion of a corn plant badly infected with corn smut. The diseased parts or the entire diseased plants should be cut off and destroyed.

CORN SMUT

One can readily detect the presence of this fungus, because of the prominent and sometimes enormous swell-

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FIG. 170. Bean pods infected with bean anthracnose. The diseased portions often extend through the walls of the pod and affect the seed within.

ings produced. These somewhat rounded but irregularly shaped enlargements may appear on leaves, stalk, tassel, or ears. At first, the outside of these swellings is glistening white, but later the mass breaks up into black powdery substances, largely composed of minute spores. These spores live over winter and lead to the infection of growing plants the next year. The filaments of the fungus gain entrance anywhere in the growing parts, especially through wounds. The fungus grows rapidly, and the parts in which it feeds become enlarged and greatly distorted. The effect of this fungus differs very much from that of such a fungus as the downy mildew of the cucumber, which kills tissues and does not first cause them to become enlarged.

To prevent the spread of this smut, do not allow any pustules to mature and shed their spores. Cut out the

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FIG. 171. Bean seeds showing anthracnose spots. If these seeds are planted, the disease will be transmitted to the plants of the next crop.

swellings when they are "green" and immature, and destroy them by burning.

BEAN ANTHRACNOSE

The most common and perhaps the most destructive of the diseases that attack varieties of the common or kidney bean is the disease known as *bean anthracnose.* It is nearly always present on some varieties. The fungus attacks pods, stems, leaves, and even roots, causing discolored blotches to appear. On the pods these first appear as small, dark-colored spots which soon increase in size, becoming quite conspicuous. They are usually somewhat circular and black or rusty, but may be pinkish at certain stages. These "cankers," as they are called, become sunken and dry and hard. It is in these areas that the fungus is living. Spores are produced on the surface of the canker; and as these are sticky when wet, they are easily spread, much in the same way as the spores of the tomato-leaf blight are spread. The filaments of the fungus penetrate to the interior of the pod and infest the seeds, and here they may remain, ready to thrive on the young plant when the seed germinates.

Control. Do not cultivate or hoe the crop, or pick the pods when the plants are wet from rain or dew, as this spreads the spores from plant to plant. Burn all badly infected plants and destroy the vines of others as soon as the crop of pods is harvested. This helps to check the spread of the disease to later crops.

The chief means of prevention is through *seed selection.* The fungus is carried over winter on the seed, and the very first leaves (the seed leaves or cotyledons) may already have the fungus present in the seed. Do not save seed from infected pods. This is one of the seed-borne diseases whose presence can often be detected with the unaided eye. Examine carefully the seed that is bought for planting, and reject all seeds that show dark or reddish spots indicating the cankers of the fungus. Seed treatment with fungicides has not thus far proved successful in controlling this fungus. The filaments penetrate deeply into the embryo itself, and a treatment which destroys the fungus also usually kills the embryo.

PREVENTING PLANT DISEASES

From the above discussion of the diseases typical of plants grown in the vegetable garden, it will be evident to the reader that there is no one means of control suitable for all diseases. The best method to use is largely determined by the way the particular fungus lives and how it attacks its host. Most measures of control aim to prevent the appearance of a disease, or at least to check its spread after it has appeared. In general, the various methods which are employed and which have been noted above may be grouped in the following classes:

(1) **Sanitary measures.** The remains of diseased plants often contain countless numbers of the spores of the fungus or of the bacterium causing the disease. To leave such plant refuse scattered about the garden or in piles about the border often assists the fungus or bacterium to live over winter, and thus invites a reappearance of the disease. On this account the garden should be kept clear of plant refuse, and the remains of plants known to be infected should never be used in a humus pile. Hotbeds, cold frames, and flats should be thoroughly cleaned out at the end of the season; and they should be sprayed or sprinkled with weak solutions of formaldehyde. Sanitary measures are as desirable for the garden as for the household.

(2) **Crop rotation.** Through rotation in the planting of crops it is often possible to kill out the fungus by not planting a crop that serves as a host for it. This is especially the case when a parasitic fungus lives, in some form or other, for a considerable time in the soil where the best sanitary measures are of little avail. In larger gardens and on a farm, various crops can be shifted to different locations from year to year. In a small garden there is less chance to practice crop rotation. But even here it can be practiced to some extent. For example, late cabbage should not be planted in soil on which an early crop showed infection with the clubroot disease.

(3) **Seed treatment.** The aim of this method of disease prevention is to destroy the parasites that exist in some form either on or in the seeds. Soaking seed in hot water or in solutions of certain chemicals will often kill these parasites. There is, however, danger of injuring the seeds, especially if they are allowed to soak too long or if they are not properly dried afterward. The treatment most effective differs widely according to the kind of seed and the kind of fungus. Seed treatment is useless when seeds are planted in infected soil. Corrosive sublimate, sometimes used in seed treatment, is a deadly poison. Formaldehyde is extremely irritating to the skin and to the nose and eyes. Seed treatment should not be undertaken by the beginner in gardening without considerable study of the literature and without a special demonstration or study of the methods. *Children should never attempt the work alone.*

(4) **Fungicides.** The use of fungicides, of which Bordeaux mixture has already been mentioned, has now become very general in combating various fungous diseases. This aims chiefly to destroy the fungus at the time it is gaining entrance to the leaves. The chemicals applied stick to the leaves after the surface becomes dry. When the leaves become wet from dew or rain, the poisons are dissolved in the films of water that cover the leaves. The poison is therefore present to destroy spores which may lodge and germinate in the water. Sooner or later the poisons which were applied are washed from the plant; therefore the gardener must spray repeatedly, and most often when diseases are especially destructive or the weather rainy.

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FIG. 172. In a field of cabbage that was almost entirely destroyed by yellows, a plant that had formed a good head was found. This plant was saved for seed.

The most successful truck growers often spray crops subject to diseases that can be thus controlled, whether disease is present or not. They do this to prevent any appearance of disease. The home gardener should be prepared to use fungicides whenever diseases appear that can be thus controlled. Children should not be intrusted with the task, but should have the help of some older person, as a parent, teacher, supervisor of garden work, or scoutmaster.

(5) **Varieties resistant to disease**. Sometimes certain plants of a crop are able to resist the attacks of a parasite, while the greater number of sister plants all about suffer or die. If seed is saved from these more resistant plants, a highly resistant variety may be obtained. The work of developing such resistant strains is best

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FIG. 173. The rows of cabbage at the right were grown from seed from resistant stock. They have inherited the power of the parent plants to resist the disease. The plants on the left are from ordinary seed.

conducted by agricultural experiment stations or by seed firms that produce seeds on a large scale. However, the home gardener may secure seed, whenever available, of desirable varieties known to be resistant to certain diseases. When a disease tends to reappear year after year, resistant varieties are especially valuable. For example, the fungus that causes the "yellows" of cabbage is believed to persist in infected soil for a number of years, and the growing of cabbages in such soil is only possible when one uses seed of plants that are resistant to this disease (see Figs. 172 and 173).

Whenever any noticeable and markedly injurious fungous disease or insect (see next chapter) appears among any of the vegetable crops, one should determine without delay the nature of the injury. If this cannot be determined with reasonable certainty from personal knowledge, from such literature as may be at hand, or from persons who may readily be consulted, then the county agricultural agent or the state agricultural experiment station should be written to. When writing for information, it is well to send specimens from diseased plants (or if the trouble is caused by insects, a few of these), with a full description of the conditions.

Although children cannot be expected to handle poisons used in seed treatment or in sprays, they can observe how these remedies are applied and they can readily learn to recognize the symptoms of many diseases and insect pests. If there is a microscope in the school, demonstration of the spores of many parasitic fungi may readily be made. Such a demonstration may often be arranged through school authorities or through the county agricultural agent. An acquaintance with the world of microörganisms all about us may well be begun in this manner.

Questions

Why are the garden plants considered as belonging to the higher forms of plant life? Name some seedless plants. Name some common plants that do not have green coloring matter. How do fungi reproduce?

What are parasites? Why did the causes of many plant diseases long remain a mystery? How may the gardener recognize the presence of disease in his plants?

How does the clubroot disease of cabbage affect the plant it attacks? How is it controlled? How can the clubroot disease be distinguished from the root-knot disease of cabbage? What causes bacterial wilt of vine crops? Describe the activities of the parasite. How does it gain an entrance to the host plant? What are the best means of controlling the disease? Describe the effect of bean blight. How is it controlled? What is the "black rot" of cabbage? Describe the effects of the downy mildew of cucumber.

How is Bordeaux mixture prepared? What are the general rules for using this fungicide?

Describe the appearance of a tomato plant affected by the tomato-leaf blight. How is the disease spread? How is it controlled? What is a "damping-off" disease? How is it prevented? Describe the appearance of the corn-smut fungus. How can the spores be prevented from spreading? What is bean anthracnose? What are the methods of control?

Why is there no one means of controlling all plant diseases? What are the sanitary measures of controlling [plant diseases? How does crop rotation assist in keeping plant diseases in check? How may seeds be treated for diseases they are carrying? Why should children never attempt this work alone? What are the general principles involved in using fungicides? How are disease-resistant varieties of crops developed?

Things to Do and Observe

1. *To learn to recognize the symptoms of the various diseases of garden vegetables.* Watch for the earliest appearance of a plant disease. If at any time a plant looks as if it were diseased, try to learn what disease it is, either by referring to a garden book or by asking an experienced gardener; or, if you cannot find out in any other way, send specimens of diseased plants to the state agricultural experiment station for identification, and ask for information. In this way you will get into the habit of watching for the appearance of disease in your plants and you will know just what to do as soon as you recognize the disease.

2. *To learn how to control plant diseases.* Secure bulletins from your state department of agriculture on the diseases of garden vegetables and their control. Consult the local dealer as to the kind of sprayers and fungicides he sells. Inquire among gardeners as to which of these are most effective.

CHAPTER NINETEEN

INSECTS IN THE GARDEN

He is rather handsome as bugs go, but utterly dastardly.

CHARLES DUDLEY WARNER

VARIOUS insects attack garden plants, and if left alone, these insect enemies may seriously injure crops or even destroy them entirely. The gardener therefore needs to know what insects attack the different vegetables, how to tell when they are present, and what to do in destroying or controlling them.

In the course of their lives, insects pass through remarkable changes in form and appearance. Often the habit of living and feeding entirely changes in passing from one stage to another. In general, the best methods of combating any given insect depend on its life history and how it feeds at the time when it injures the plants. In this chapter, therefore, we shall study the life history and feeding habits of some of the insects that are of most interest to the gardener and learn the best ways of protecting garden plants from them.

THE CHEWING INSECTS

The chewing insects are those which at some stage of life chew or bite into plants from the surface. They may therefore be killed by poisons sprayed or dusted over the plants which they are eating. Other methods of controlling them may be used, depending, as we shall learn, on the way the insect lives.

The cabbage butterfly. Cabbage plants, especially in late summer, are often infested with greenish-colored caterpillars, commonly spoken of as "cabbage worms." These caterpillars have such hearty appetites that they often completely strip the leaves of young plants, checking their growth and preventing the proper formation of

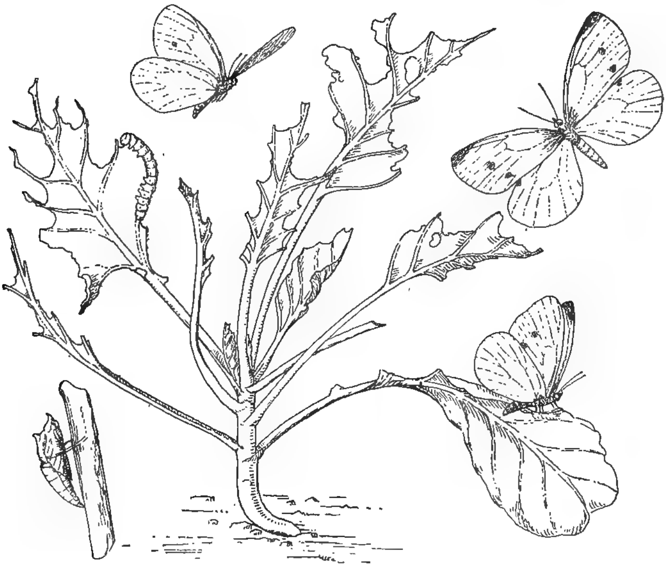

FIG. 174. Different stages in the life of the cabbage butterfly.

heads. On older plants they burrow from leaf to leaf among the outer leaves of a head, leaving castings that make the heads undesirable as food. The caterpillar increases in size, shedding or molting its skin several times as it grows, until in 2 or 3 weeks it is an inch or more long.

When fully grown, a caterpillar attaches itself firmly by a few silken threads, sheds its skin again, and incloses itself in a thin but tough and horny covering. It is now a *pupa* (plural, *pupæ*) or, as it is also called, a *chrysalis* (plural, *chrysalides*). Before it passes into this stage the caterpillar usually leaves the plant upon which it has been feeding and crawls up some object, as a tree, a fence, or a building.

The pupal stage is the resting period of the insect's life; when in this stage it does not eat, and appears to be inactive and dormant. But within the thin shell wonderful changes are taking place, and in time a butterfly develops and comes forth. This is the mature or adult form of the insect.

The cabbage butterfly is white above and white or yellowish beneath, with a wing spread of about 2 inches. The male has one black spot on each of the four wings. The female has an extra spot on each of the front wings. These butterflies may be seen flitting about the garden almost any day during the summer. In the butterfly stage the insect does not feed upon the cabbage plants; its food is now obtained from the nectar of flowers.

When the female is ready to lay eggs, she alights on the edge of a cabbage leaf and glues the eggs, one at a time, in different places on the lower surface. A butterfly has been known to lay as many as 125 eggs in a single day, but of course not all of these are placed on any one plant. The eggs are about $\frac{1}{25}$ inch in length. In from 3 to 10 days the eggs hatch; tiny caterpillars emerge and immediately begin feeding.

In its life cycle, this insect passes through four rather distinct forms: (1) the *egg;* (2) the *caterpillar* or *larva* (plural, *larvæ*), which is often incorrectly called a worm; (3) the *pupa*, or so-called resting form; and

(4) the *butterfly* or *adult* form. The appearance of the same individual insect and its habits of feeding and living are very different in the various stages of its life.

In the northern states the cabbage butterfly lives over winter in the pupal stage. The pupæ that are formed late in autumn remain in this stage until late in the following spring. During the summer, however, the butterflies emerge from pupæ in from 7 to 10 days; consequently there are in the North at least two generations in a season.

In the southern states, where the winters are very mild, there may be as many as six generations in a year; the butterflies and the caterpillars of this insect are therefore present throughout the year.

The cabbage butterfly may be fought both in the adult and in the larval stage. The following methods are recommended:

(1) *Catching the butterflies.* The butterflies are active in their movements, but they may be captured in butterfly nets as they flit about the garden. Special efforts to catch the females at the time when eggs are being laid will often greatly reduce the later work of killing the caterpillars.

(2) *Hand-picking the caterpillars.* The caterpillars are sluggish in their movements and can readily be picked off the leaves and destroyed. At first they are minute, and their color is almost the same as that of the leaves upon which they feed, but as they grow larger they are more easily seen.

A simple means of killing the caterpillars is to drop them into a dish containing water and a little kerosene.

To hand-pick successfully, the plants should be searched repeatedly, beginning as soon as signs of the insect are seen.

(3) *Use of poisons.* Poisons are often used to kill chewing insects, and for some insects the use of a poison is the best means of control. How to mix poisons and

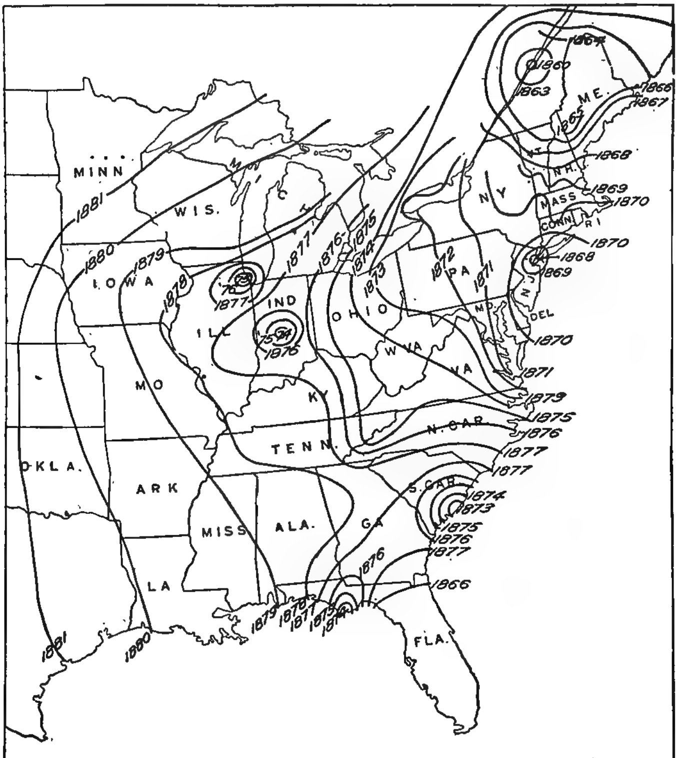

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FIG. 175. Map showing the rapid spread of the cabbage butterfly. It first appeared at Quebec in 1860, and, spreading southward and westward, by 1881 it was found over half the continent.

apply them to plants may be explained in this connection.

To use Paris green dry, mix it in the proportion of 1 part to 10 parts of dry air-slaked lime, and dust the mixture liberally over the plants while the dew is on. A tin sifter or duster for use can be bought for less than a dollar. A good duster can be made, however, by punching small holes in one end of an empty baking-powder can, by constructing a bag made of cheesecloth, or by folding together the edges of a piece of loosely woven burlap. Place the poison within the duster or bag and use as a shaker.

Paris green may be applied also as a liquid spray. Melt 1 ounce of common laundry soap in 4 gallons of hot water. When the mixture is cool, add 1 ounce (about 5 heaping teaspoonfuls) of Paris green, stir well, and apply by means of a compressed-air or auto sprayer. Good sprayers of small size costing from one to two dollars are listed in the catalogues of seed firms.

Arsenate of lead is another effective poison, and it is sometimes cheaper than Paris green. To use it dry, mix 1 part of powdered arsenate to 3 parts of air-slaked lime. To make a spray, use 1 ounce of the arsenate of lead to 3 gallons of soapy water. The soap in the water is needed to make the solution stick to the leaves of cabbages instead of rolling off their smooth, waxy surfaces.

White hellebore is very generally recommended as a poison for chewing insects. It may be applied as a dry powder or in a spray, using 1 ounce of powder in 1 gallon of water. It is often stated that this poison soon loses its activity when exposed to air and becomes harmless. If this were true, white hellebore would be especially valuable for use on salad vegetables. There is, however, considerable doubt that it becomes harmless in a short time, and for this reason its application on leaves that are to be used as food is to be safeguarded, as noted in the next paragraph.

Caution. Paris green, arsenate of lead, and white hellebore are *deadly poisons* to human beings. All supplies of these materials should be kept where children cannot obtain them. In the home garden, poisons should be used only when no other means are effective, and then only by experienced persons.

When these poisons are used in the dust form, children should be careful not to get dust in their own faces or in the faces of others. Leafy crops should be sprayed with poisons only when young, long before they are to be used as food. Poisons should not be applied to cabbages after the heads are beginning to form.

Cutworms. Cutworms often do much damage by chewing through and cutting off the tender stems of young plants of beans, corn, tomatoes, onions, sweet potatoes, and cabbages. These " worms " are the caterpillars or larvæ of night-flying moths. During summer evenings they often fly through open windows into a room and flit about a lighted lamp.

The eggs are laid in late summer; the young caterpillars that soon hatch from them feed during autumn chiefly on the roots of grasses, and then live over winter as half-grown caterpillars. Hence cutworms are almost sure to be present in a garden that was in sod the previous year. In the spring they crawl over the surface of the

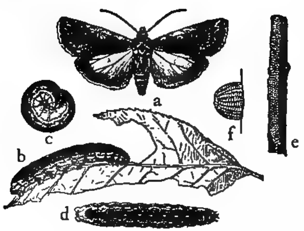

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FIG. 176. Life history of the variegated cutworm: *a*, adult moth; *b*, larva in the injurious stage, feeding; *c*, larva coiled up, a characteristic position when resting in the ground; *d*, top view of larva, showing the six little white dots on the back; *e*, egg mass on a twig; *f*, side view of an individual egg, much enlarged.

garden during darkness and feed by chewing through the stems of young plants. After feeding, they burrow into the soil, where they curl up and remain quiet during the day. There are several ways of overcoming cutworms.

(1) *Protection from attack.* A stiff paper cylinder or collar 3 inches in height, set into the ground about a plant, will afford protection, for the worms rarely climb over it. This method is feasible for protecting transplanted plants of cabbage and tomato, but not for crops grown from seed planted in the garden.

(2) *Killing the caterpillars.* By carefully scraping away the dirt from around the bases of plants that have been cut off during the night, one can often find the caterpillars and destroy them (see Figure 10). A search for cutworms should be made early in the morning.

(3) *Use of poisoned bait.* This method is sometimes used in commercial gardening, but its use is seldom necessary in the small home garden if the methods noted above are vigorously employed. To make poison bran mash, mix 3 teaspoonfuls of Paris green with 1 pound of dry wheat bran. Dissolve 2 teaspoonfuls of salt and 5 of sirup in a teacupful of water. Mix all together and add enough water to make the mash crumbly. This poisoned bait is scattered over the ground every evening during

the season when the caterpillars are causing injury to crops.

One of the most common species of owlet moth in the United States is the "dingy cutworm." The moth is a buffy and dingy gray color, and the caterpillar is a light drab color. Many other kinds of cutworms may be found in the garden.

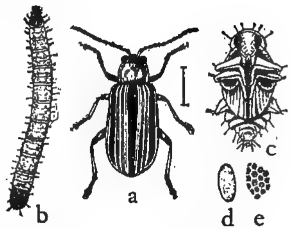

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FIG. 177. Life history of the striped cucumber beetle: *a*, adult beetle; *b*, larva; *c*, pupa; *d*, egg, much enlarged; *e*, markings on the egg as they appear when egg is highly magnified. The short black line in the center of the picture gives the exact length of the adult beetle; the larva and pupa are correspondingly smaller than they appear here.

The striped cucumber beetle. This insect does much injury to cucumbers, muskmelons, watermelons, pumpkins, and squashes, and also sometimes to beans, peas, and corn. Early in spring the beetles come forth and live on various weeds until the vine crops start to grow in the garden. Then they feed so ravenously upon these that the entire crop may be destroyed in a few days, almost before the young plants show above ground. This beetle occurs over the greater part of the United States and is the most destructive insect enemy of the vine crops.

The eggs are laid in late spring. They hatch in about 10 days into grubs, which feed by burrowing into or feeding on the stems and roots of vine plants, and also by eating into the fruits. The larvæ are white, with a brown, horny head. They are long and slender, not short and thick like the larvæ of the squash borer, described later. After about a month, they pass into the resting stage, which lasts until late summer or autumn. Then the mature beetles appear and live through the winter under such rubbish as dead plants, mats of grass, or even boards that may be lying about. The beetle is only about $\frac{2}{5}$ inch long. Its color above is yellow, with a black head and a black stripe along the edge of each wing cover. When the wings are closed, these colors give the back the appearance of having three stripes.

The striped cucumber beetle passes through four stages, quite the same as does the cabbage butterfly; but it is of course a very different type of insect, both in appearance and in habits. It is most injurious to vine plants when in the *adult* stage, and it is then that it is most easily destroyed.

The five following methods of fighting the striped cucumber beetle are the most effective that gardeners know:

(1) *Early spraying.* In spring it is well to spray the plants of cucumbers and squashes, as soon as they appear above the ground, with a solution of arsenate of lead of a strength of 3 ounces to 5 gallons of water. As an ounce of arsenate of lead is equal to about 5 heaping teaspoonfuls, the solution is made with 3 spoonfuls to 1 gallon of water. Paris green is not used, because it is likely to injure the leaves of cucumbers and squashes.

(2) *Use of trap plants.* As the beetle prefers to feed on the squash, hills of the summer squash or the Hubbard squash may be planted among the cucumbers to act as "trap plants." Then, when the beetles are feeding on these, a sudden application of a spray of pure kerosene will catch them and kill them before they can escape.

The trap plants also will be injured or even killed, but they will have served their purpose.

(3) *Protection by covering.* During the early stages of their growth, young plants of the vine crops may be protected by frames covered with cheesecloth.

(4) *Late spraying and hand-picking.* In the autumn, large numbers of the adult beetles may be killed by spraying or dusting late-growing plants of the Hubbard squash with arsenate of lead. The beetles collect also on immature fruits left in the garden; and on cool mornings, about the time of the first frosts, these insects are sluggish with the cold. At such times the fruits may be picked and the clinging beetles brushed into a pail of water and kerosene. The common squash bug and the twelve-spotted cucumber beetle also may be destroyed in considerable numbers at the same time.

(5) *Burning old vines.* After the vines have been killed by frost, they should be raked into piles and left for several days; then, with the addition of brush or straw, the piles may be burned quickly, thus killing the beetles that have taken refuge within. During late autumn the gardener is likely to become careless regarding the use of remedies against insects; but he should remember that "a stitch in time saves nine."

Other chewing insects likely to injure garden crops. The potato beetle is nearly always present on potatoes and feeds vigorously both in the adult and in the larval stages. Methods for the control of the potato beetle have already been mentioned (page 280).

Two kinds of beetles are injurious to asparagus, feeding in both the larval and adult stages on young shoots and mature plants. Various sorts of tiny "flea beetles" eat holes into the leaves of eggplants, squashes, cucumbers, melons, snap beans, and tomatoes. These insects are best destroyed by sprays of arsenate of lead.

The blister beetles of the beet and Swiss chard are black or striped beetles about $\frac{3}{4}$ inch in length. They often "come in droves," and if unchecked, soon do much injury. It is not advisable to spray Swiss chard with poisons, but the insects may be caught by beating and shaking from the plants into a wide-mouthed pail containing water and a small amount of kerosene.

THE SUCKING INSECTS

The insects which are known as the "true bugs" have their mouth parts arranged in the form of a tube-like beak. Those that live upon plants feed by inserting this beak into the plant and sucking out the juice. They are therefore not injured by poison on the surface of the leaves, but must be sprayed or dusted with something that will kill them by coming in contact with them. Kerosene emulsion and preparations containing nicotine are most generally used for this purpose.

Aphids. The most common sucking insects in the garden are the plant lice or aphids. There are many kinds of aphids that attack plants. Some feed upon roots; others on the parts that grow in the air, mostly on tender young leaves, buds, or fruits. They are all rather small and feed wholly on plant juices. In the North they live over winter in the egg stage, but in the more southern states they are present in the adult stage throughout the winter as well as in summer.

FIG. 178. Showing how aphids stunt the growth of seedlings. These two cabbage plants were started at the same time; the one at the left was allowed to become infested with aphids, but the one at the right was kept free from them.

In the vegetable garden, plant lice are often abundant on peas, on melons, cucumbers, and other vine crops, and on spinach and cabbage. The insects feed chiefly on the under surface of the leaves, which often become irregularly curled and shriveled through their work. Badly infested plants do not thrive, they often fail to produce good crops, and they may die prematurely.

Aphids are usually overcome with sprays made from tobacco preparations. These are sold in the market under various trade names. One of the best known and most powerful is "Black Leaf 40." Nicotine sulfate, made from tobacco, is much used in making insect sprays. To use it, dissolve 1 ounce of soap in a gallon of hot water, and then add 1 teaspoonful of the nicotine sulfate. A small package of smoking tobacco boiled in

3 gallons of water with an ounce of soap will make a solution that will kill plant lice. This solution should be strained before using, to prevent clogging of the sprayer.

Kerosene emulsion also may be used to kill aphids and other insects, but it is not so convenient to make up as the tobacco preparations. To prepare it, boil $\frac{1}{2}$ pound of laundry soap in 1 gallon of water until dissolved. Remove from the fire and add 2 gallons of kerosene. Pour the kerosene into the water slowly, adding small amounts at a time. Stir constantly and thoroughly, and in about 5 or 10 minutes the mixture will become thick and creamy. This stock solution may be kept stored for use at any time. Dilute with from 10 to 20 parts of hot water, stir well, and use as a spray. Both the kerosene and the tobacco sprays should be cool when used on the plants.

To be effective, these sprays must reach the body of the insect. They should be applied as a fine, mist-like spray, such as a good compressed-air spray pump will throw. The under surface of leaves and the inclosed portions of rolled-up leaves should be reached, so that all insects present will be touched by the spray. Several applications of spray at intervals of 2 or 3 days may be required to rid plants of aphids.

The common squash bug. The full-grown adult of the common squash bug is about $\frac{3}{4}$ inch long; it is of a dirty grayish-brown color above and a yellowish color beneath. It gives off, especially when handled, an offensive odor. The mouth parts are formed into a conspicuous beak about $\frac{1}{4}$ inch long. This beak is characteristic of the sucking insects; with it, they puncture plants and suck juices from within.

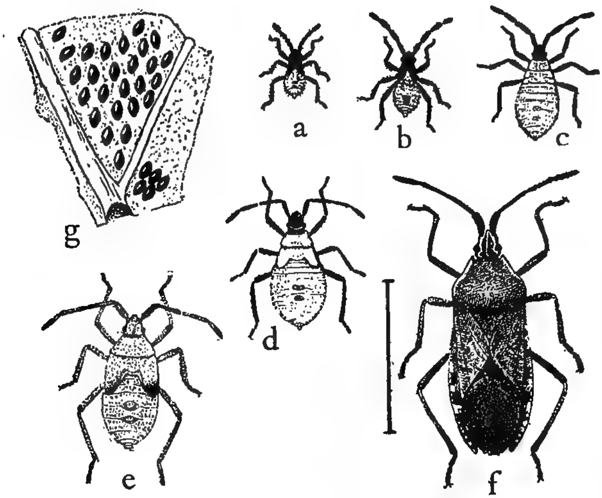

FIG. 179. Life history of the common squash bug: *a*, nymph soon after hatching from egg; *b*, second stage of nymph; *c*, third stage of nymph; *d*, fourth stage of nymph; *e*, fifth stage of nymph; *f*, adult; *g*, egg mass on the under side of a squash leaf. All the figures are about one and a half times natural size.

The adult insects live over winter, hidden in and protected by rubbish of various sorts. The small, coppery-colored eggs are laid mostly on the under sides of leaves of squash plants and usually in groups of thirty or more. Young bugs or "nymphs" appear in about 10 days, and immediately begin to feed on the host plant. After molting five times, which covers about 35 days of feeding, the nymphs become adults. They thus pass from egg to adult without the resting or chrysalis stage.

This insect is injurious through its whole life, except when dormant in winter. It is found throughout the

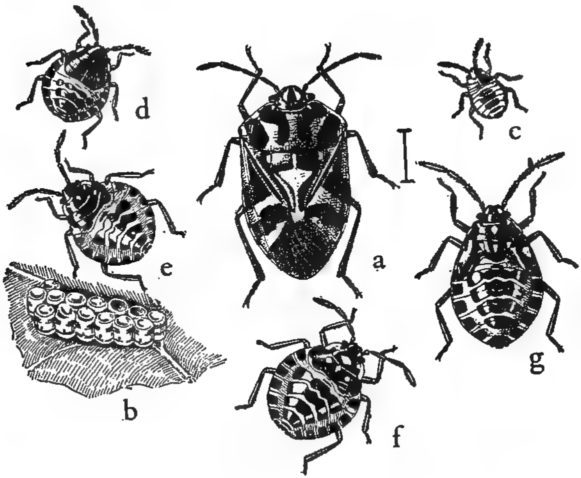

Fig. 180. Life history of the harlequin, or calico-back cabbage bug: *a*, adult; *b*, egg mass; *c*, first stage of nymph; *d*, second stage; *e*, third stage; *f*, fourth stage; *g*, fifth stage. All enlarged.

entire United States and is reported to be most abundant east of the Rocky Mountains.

Unfortunately the common squash bug resists kerosene and nicotine sulfate sprays, but the following methods of control are effective when carefully carried out:

(1) *Hand-picking*. The adult bugs are picked from the vines throughout the season, or if pieces of board are placed in the garden, especially during spring and early summer, the insects gather beneath them. Collect and crush the eggs also.

(2) *Clean culture.* Clean culture also should be practiced. In the autumn place the squash vines in small piles scattered about the garden. Allow them to lie until after several hard frosts, and then burn them.

The calico-back cabbage bug. The "calico bug," "fire bug," "terrapin bug," or "harlequin bug" is the most destructive insect of the various cabbage crops, and also of the turnip, radish, and mustard, throughout the southern part of the United States. It saps the juice from the veins of leaves and often causes plants to wilt and die as if swept by fire. Its gay red and black coloring makes it conspicuous and easily recognized. In general, its habits and life history are quite similar to that of the common squash bug described above. In the South it is active throughout the season, but near its most northern range (about the latitude of Washington, D. C.) it is dormant for a time in winter.

There are three good methods of controlling the calico bug:

(1) *Hand-picking.* This is effective, especially when adults appear on a crop before they have laid eggs. Growers in various parts of the South have paid bounties to school children for gathering them, and it is reported that as many as 47,000 of these bugs were thus collected for a grower at Denton, Texas, during one month (February). The egg masses laid on the under side of leaves are rather conspicuous, and these also may be gathered and crushed.

(2) *Use of trap crops.* Early and late crops of mustard may be grown among the plants largely for the purpose of attracting the calico bug. The insects collect on the

mustard and may be destroyed. In this way crops of cabbage are protected in spring. In the autumn late crops of mustard will attract the bugs at times when other food may be scarce.

(3) *Clean culture.* The advice given for clean culture, under methods of combating the common squash bug, will be helpful also in keeping the calico bug under control.

Gardeners living in the zone just north of the present range of the insect should keep a sharp watch for its appearance. Determined efforts should be made to prevent its further spread.

THE BURROWING INSECTS

The larvæ of many insects live within the plant and cannot be killed in their feeding stage by poisons or sprays. To combat them it is necessary, therefore, to keep the adults from laying eggs among the plants, to destroy them when they are outside the plant, or to remove them from their tunnels by hand and kill them. Several kinds of burrowing insects are troublesome to garden plants, and some of these are often very injurious.

The radish maggot. The roots of radish and cabbage plants are attacked by "maggots," which eat grooves in them or even tunnel into the inside. Young cabbage plants may thus be killed, and infested radishes are stunted and made worthless as food.

The adult of this maggot is a *fly* (somewhat smaller than the common house fly) which appears in the spring. It lays its eggs in the soil, usually near plants of the radish or the cabbage, and the eggs hatch in from 3 to

5 days. The young maggots feed on or within the roots, but when fully grown they usually leave the plants and burrow out into the soil, where they change to the pupal or dormant stage. During the summer months, the pupa lies dormant only from 12 to 18 days, and then the adult flies appear. Thus, several broods are produced in a season. The pupæ that are formed in the autumn live over winter in the ground. The following methods are used in the control of the radish maggot:

(1) *Protection by covering.* Beds of radishes or cabbage plants grown in cold frames, or outdoor beds of these plants, may be protected from the flies by placing over them a board frame covered with cheesecloth.

(2) *Prevention of egg laying.* It is believed by some that the flies will not lay their eggs in soil upon which a little kerosene has been sprinkled. To apply the kerosene, pour a cupful of it over a pail of dry sand, mix well, and scatter the sand over the soil about the plants.

(3) *Disks of tarred paper.* Cabbage plants may be protected by covering the earth about the roots of the plant with disks of tarred paper about 4 inches in diameter. These should be fitted closely about the stem of the plant when it is placed in the field.

(4) *Killing the maggots in the soil.* The maggots that are in the soil may be killed by pouring kerosene emulsion or corrosive sublimate solution (1 part of corrosive sublimate to 1000 parts of water) over the bed or row until it soaks down into the soil about the main roots of young plants. Another effective solution, which may be used in the same manner, is made as follows: mix a pint of crude carbolic acid in a gallon of hot water, then add a bar of

laundry soap and stir until soap is all dissolved. After the solution has become cool, dilute to make 12½ gallons.

(5) *Treatment of infested crops.* After a bed of radishes becomes infested, it is best to pull and destroy all infested plants immediately, and to apply a solution that will kill the maggots that are in the soil.

The squash borer. Both the summer and the winter squashes are attacked and often destroyed by the larvæ of the squash borer. The plants attacked soon wilt badly and usually die within a few days. An examination of such plants will reveal discolored and dead areas in the stem, especially near the ground. The stem within is much eaten out by plump white "grubs" or larvæ, which may be found if the stem is split open.

These borers feed within the stems during summer and

FIG. 181. Summer squash plants killed by the squash borer.

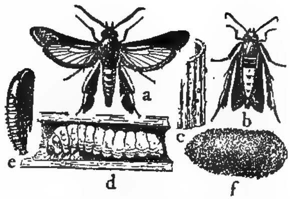

FIG. 182. Life history of the squash borer: *a*, adult male moth; *b*, adult female moth; *c*, eggs, as they appear on the surface of a squash vine; *d*, full-grown larva within a portion of the vine; *e*, pupa; *f*, outer cell surrounding the pupa. All the figures are about one-third natural size.

autumn. When fully grown, a grub leaves the plant, burrows into the soil, and spins a silky cocoon, within which the pupa forms. Thus it lives over winter. Late in the following spring (in June in New Jersey, but earlier southward and later northward) a beautiful clear-winged and wasp-like moth emerges from the cocoon and escapes from the soil. This moth is about 1 inch long, with a wing spread of $1\frac{1}{2}$ inches. Its hind wings are transparent, but the fore wings are opaque and of a brownish color. The adult moth is most readily identified by a conspicuous fringe of orange-colored hairs along the inner side of the hind legs.

The moths are active during the day but become sluggish toward nightfall, and in the evening they settle on the upper side of the leaves and rest during the night.

The female moth lays small, dull-red oval eggs along the stems of squash plants, usually near or even just below the soil. The eggs are large enough to be seen with the naked eye if one looks closely. The eggs hatch in a few days, and the grubs burrow into the stem, where they feed. They eat out the tissues that carry soil foods and water to and from the leaves, and the plant soon suffers. If several larvæ are present in a single stem, the plant usually dies.

FIG. 183. Vine of a summer squash laid open to show the borers. At the right a full-grown borer is shown.

In the more northern states there appears to be one brood of the squash borer. Farther south there are two, and in the more southern states there seem to be several broods hatching at different times. Thus the adults appear and lay their eggs in broods, and the larvæ are present throughout most of the growing season for squashes. In some sections this insect is so troublesome that it is almost impossible to raise squashes.

Because of its habits the squash borer is difficult to control. However, if the following directions are carefully carried out, it may be kept somewhat in check:

(1) *Learn to know the moths.* Watch for them. If they are seen in the garden, go over plants every evening or early in the morning and kill all the adults found resting on the leaves.

(2) *Examine the stems of squash plants for eggs.* If any are found, remove them with the point of a knife, holding a dish beneath to catch them as they fall, and then destroy all the eggs as soon as they are collected. Or instead, the eggs may be crushed by rubbing them against the stem.

(3) *Kill all grubs that may get into stems.* To obtain these grubs, split the stems of infested plants halfway open from one side. If only a few grubs are present, they may be removed without killing the plant by carefully slitting the stem. If plants are badly infested and sure to die, either dig out all larvæ or completely destroy the entire plant and the larvæ within it by burning.

(4) *Help plants to resist the attacks of the borer.* The winter squashes that make long vines, and also to some extent the summer squashes, can be rooted at the joints. As the stem grows, cover the joints with soil; roots will form, and these will supply water and minerals to the leaves even though the stem portions near the main root may be badly infested, or much injured in digging for the larvæ.

(5) *Cultivate to kill the insect in the pupal state.* In autumn dig up and rake over the soil on which infested plants have grown, in order to bring the cocoons to the surface where the winter weather may kill them. In spring spade deeply, turning the top soil under so as to bury the cocoons so deeply that the moth cannot emerge.

Other burrowing insects. There are several other insects that damage garden plants by burrowing into the stems of stalks.

The larvæ of a *stalk borer* burrows into the stems of the tomato and the potato. The stem soon wilts and dies above the place where the insect entered; so one can tell when a borer is in a plant. By slitting open the stem the insect may be found and destroyed early in its life.

The *seed-corn maggot* burrows into the roots and stems of young plants, especially corn, beans, and cabbage, causing them to wilt and die. Pull up all infested plants and destroy the larvæ. The methods advised for combating the radish maggot may also be used for this maggot.

The *carrot-rust fly* attacks carrots, celery, parsnips, and parsley, feeding in the tender roots and burrowing into large roots of older plants. There is no very good method of control, except perhaps that of growing the crop under a frame completely covered with cheesecloth.

The *European corn borer* has recently been introduced into several eastern states, and there is danger of its spreading throughout the country. If it is not checked, it may become a serious enemy of the corn grower. The larvæ burrow into the stalks, ears, and even the seeds. As many as 311 borers have been found in a single hill of corn. Such a destructive insect should be vigorously fought, and its presence should be reported immediately to the state agricultural college, to a county agricultural agent, or to the Bureau of Entomology, United States Department of Agriculture, for instruction as to the best measure of control.

BENEFICIAL INSECTS

Not all of the insects seen in the garden are injurious to garden crops. Some are very helpful, for they feed upon injurious insects and thus help to keep them in check. A gardener should learn to recognize these beneficial insects, so that he may preserve and protect them.

Parasitic insects. Many garden insects are preyed upon by other smaller insects that feed upon the living tissues of their bodies. The large caterpillar that lives on the tomato (and sometimes on the potato) may often be seen with its back covered with small white oblong bodies that at first glance may be mistaken for eggs. These are the cocoons of the larvæ of a very small fly (one of the *Braconids*). The fly punctures the body of the caterpillar and lays its eggs under the skin. Then the larvæ hatch and feed upon the caterpillar's body. A caterpillar that has been thus parasitized often dies.

Empty shells of plant lice (aphids) may often be found clinging to the leaves of plants. These have been destroyed by another kind of Braconid. The mother insect finds an aphid and forces her eggs into its body. The eggs soon hatch, and the larvæ feed within the aphid and kill it. The pupæ form inside the aphid after it has died, and when the adults develop they cut a circular opening in the inclosing shell and fly out to lay eggs for another generation. Wherever aphids are abundant, the shells showing that the Braconids are at work on them can nearly always be found.

The lady beetles or lady bugs. Most lady bugs (or more exactly, lady *beetles*) are very beneficial to the gardener. The adults are small, nearly hemispherical, and usually gayly colored with conspicuous spots. Their larvæ somewhat resemble tiny alligators in shape and are usually spotted and covered with bristling spines. Both adults and larvæ of the beneficial lady beetles feed almost entirely upon aphids. One of the lady beetles, however (the "squash lady bug"), eats the leaves of the squash, pumpkin, muskmelon, watermelon, and cucumber; and another species is injurious to bean crops in Colorado, Arizona, New Mexico, Texas, and Mexico. These injurious lady beetles should be destroyed. They may be controlled by spraying with lead arsenate, in the same way that other chewing insects are treated.

The gardener receives much assistance from nature through the feeding habits of beneficial insects and birds which destroy and help to keep in check the various insects that injure garden crops. But it is often necessary for him to take the matter of destroying insects into his own hands.

Fortunately, the gardener is able to use methods that hold in check and destroy most of the insects injurious to garden crops, and through close observation he can gain in experience and knowledge so that as soon as insect enemies appear in the garden he will know just what to do, when to do it, and how to do it.

Questions

What do we need to find out about an insect before we attempt to control it? How can the chewing insects in general be destroyed? Describe the life history of the cabbage butterfly, naming the four stages or conditions in its life. In which stage is it injurious to cabbage plants? What are the usual methods of controlling the cabbage butterfly?

How is dry Paris green prepared for use against insects? How is it used? How is Paris green prepared when used as a liquid spray? How is arsenate of lead used when dry? How is it prepared when used as a liquid spray? Describe the preparation and use of white hellebore. What cautions should the gardener take in using these three poisons ?

How do cutworms injure plants? What are the three most important methods of fighting them? How is poison bran mash made?

In what stage is the striped cucumber beetle most injurious to crops? What are the five most important ways of controlling it?

How do the sucking insects feed? How does this method of feeding injure the plant? How are they most easily destroyed? How do aphids feed? What is "Black Leaf 40"? How is nicotine sulfate prepared? How is kerosene emulsion prepared? Describe the proper way of spraying to kill aphids. Give, briefly, the life history of the common squash bug. What are the two most effective ways of controlling it? How does the calico-back cabbage bug injure the plants? What three methods are used in combating it?

Where do the burrowing insects live? What, in general, are the most effective methods of controlling them? Describe the main events in the life history of the radish maggot. What are the five best methods of combating this insect? Describe the appearance and activities of the squash borer. What methods may be used to keep it in check? What should be done if the European corn borer is found in your garden?

Things to Do and Observe

1. To become familiar with the four stages in the life history of an insect. Watch your cabbage plants for the appearance of the cabbage butterfly. When you see one hovering over the plants, try to find the egg after the butterfly has gone. Examine it carefully, with a hand lens if possible, so that you may be able to recognize others as soon as you see them. Watch the larvæ and try to determine how long it takes to grow from the egg to the pupal stage. When you have found a chrysalid, carefully remove it without crushing and place it in a small box covered with netting or cheesecloth. Look at it from time to time until the adult butterfly emerges. Note whether the butterfly is male or female.

In the same way try to recognize the four stages of as many other garden insects as possible. In some cases you may not be able to find all four stages. Become thoroughly familiar, however, with those you do find; and note particularly in which stage each insect is most destructive.

If you have not been successful in observing the four stages as they occur in the garden, make an insect cage. This will give you an opportunity to observe closely the life history of any insect you wish to study. Tie a piece of cheesecloth over the top of a large lantern chimney, and set this over a pot of earth. Place eggs, caterpillars, or larvæ of any insect within the chimney, together with a few twigs and the leaves of the plant that the insect you are studying feeds upon. Supply fresh leaves every day, and remove any that have wilted. Observe carefully the feeding habits, and watch closely the change from larvæ to pupa. Note whether the insect pupates above ground or below. If you have started with the egg stage, keep a record of the length of time between egg and pupa, and pupa and adult.

2. *To learn how the various garden insects feed.* Catch a grasshopper, a cricket, a locust, or any large beetle, and examine its mouth parts with a hand lens. Notice the two sets of jaws, one working sideways and the other up and down. Then try to find a large caterpillar (a tomato worm, a cabbage worm, or a milkweed caterpillar, for example) that is actively feeding on a leaf. Observe carefully the method of biting off and chewing. Note how rapidly the caterpillar eats and how much it consumes in a meal. Could a single caterpillar consume during its life every leaf on a half-grown plant?

With a hand lens examine an aphid, a squash bug, or a calico-back cabbage bug, while feeding. Note carefully the sucking beak embedded in the stem or leaf. By watching you may be able to see one of these sucking insects pierce the stem or leaf of the plant and settle down to feeding.

If the insects mentioned in the above paragraph are not to be found in your garden, you may be able to find one or more of the following insects which will show the sucking beak just as well: (1) a water boatman (an insect about half an inch long that swims through the water by moving two of its legs like oars), (2) a froghopper in the larval stage (look for a small insect underneath a mass of bubbles on a grass stem), or (3) a cicada (harvest fly or "locust"). Examine carefully the long beak used for piercing and sucking. (*Note.* In your search for one of these insects you may find the empty larval case of the cicada clinging to a tree trunk or post. This will show the form of the beak as well as would a live specimen.)

CHAPTER TWENTY

HOME STORAGE OF VEGETABLES

The roots must come in now, and the harvest will soon end.
Old Farmer's Almanac

A GARDEN not only provides fresh vegetables during the growing season, but it also furnishes certain crops that may be preserved or stored for future use. In this chapter we shall discuss the winter storage of root crops and other vegetables; but snap beans, peas, corn, tomatoes, asparagus, rhubarb, spinach, New Zealand spinach, Swiss chard, and summer squash may be canned. Many vegetables may also be preserved by drying, in the same way that prunes, apricots, and other fruits are preserved. In doing this work of canning and drying, the beginner should have the help of an experienced person.

Often this help is given in special classes organized to teach this phase of home economics, or it may be treated as project work in connection with gardening. The beginner may secure bulletins on the subject that will give full information concerning the methods that are used. Such bulletins are furnished by various organizations and especially by state agricultural experiment stations and the United States Department of Agriculture. The directions should be followed very carefully; otherwise the work may not be a success.

Rules for storage of vegetables. To be thoroughly successful in keeping vegetables in storage, the following rules must be observed:

(1) *Only vegetables that are in good condition should be selected.* They should show no signs of decay or disease, they should be dry, and at least moderately free from

FIG. 184. Preparing root crops for storage. Only the sound vegetables should be selected for storage, and these should not be cut or otherwise injured. Proper selection and preparation often determine the keeping qualities of vegetables stored as much as the conditions of storage themselves.

clinging earth. All vegetables should be stored before they are frozen, and carefully handled to prevent bruising.

(2) *The temperature under which they are stored should not vary suddenly or greatly.* For most vegetables it should not go above 50° F. and of course should not fall below the freezing point.

(3) *Ventilation must be provided.* More vegetables are lost in storage through failure to provide ventilation than from any other cause. Especially during the warm weather of autumn and spring, vegetables are likely to " heat " and decay if they are shut up without air.

(4) *For all vegetables except onions, sweet potatoes,*

squashes, and pumpkins the air should be rather moist. This prevents wilting and shriveling.

(5) *The storage room should be dark.* As a rule vegetables keep best in darkness. Some vegetables, like Irish potatoes, become somewhat green, and root crops may start growth if they are not kept in darkness.

Storage in the house cellar. An unheated frost-proof cellar is an excellent storage place for nearly all garden vegetables. A cellar with a furnace in it is likely to be too warm for very long storage of most vegetables, and a cool room should be partitioned off. This is usually made in one corner, with the outside walls of the cellar forming two sides. The other walls of the cool room should be tightly built of tongue-and-groove lumber, with double walls, or else made of hollow tile.

For ventilation there should be a window with a chute built into one pane and leading to the floor. This permits the entrance of cool, fresh air. A hinged door in place of another pane is provided to allow warm air to escape, thus insuring perfect ventilation. In severely cold weather these may be closed to prevent freezing.

Cabbages, beets, carrots, turnips, rutabagas, and potatoes are stored in bins or shelves built about the walls or placed in boxes, baskets, crates, or barrels that are rather loosely stacked. Packing in dry leaves, straw, or sand aids in keeping root crops in good condition. Celery, curled endive, and pe-tsai may be packed in boxes, with the roots in soil or sand. If water is added to the soil about the roots at intervals, the plants will remain remarkably fresh; but the tops should be kept rather dry, or they may rot.

The cellar without a furnace, or the cool room in a cellar containing a furnace, is undoubtedly the most satisfactory means of storing vegetables for home consumption. A dirt floor helps to keep the air moist, but if the floor is made of cement, it may be covered with 2 or more inches of sand and sprinkled occasionally.

Vegetables that must be stored in dry air. Squashes, pumpkins, and sweet potatoes keep best when stored in a *warm, dry* place. They may be placed on shelves or in crates near the furnace. Onions need a *cool, dry* place. The cool room is usually too damp for them, and a cellar with a furnace in it is likely to be too warm. They do not suffer from slight freezing and usually keep best in the attic, or even in a barn or workshop.

Outdoor storage cellars. Simple one-room cellars built so that they are dry and free from frost are often made out-of-doors. In the South they are usually built entirely above ground; in the North they are generally built partly or wholly below ground. They may be made like a cave in a side hill. Walls of stonework or concrete are desirable. The roof may be made of concrete, with a dirt covering; or of lumber, double walled and insulated with paper; or of poles and planks covered with earth and straw. Outdoor cellars are, of course, most suitable on farms and large truck gardens where there are often considerable amounts of vegetables to be stored.

A barrel storage pit. The simplest and perhaps the best outdoor storage place for the owner of a small home garden is the barrel pit. To make this, a barrel is placed

Fig. 185. Getting vegetables from a barrel storage pit during a warm day in midwinter. Note the depth of earth over the barrel, and the ventilating chimney in the center.

on its side in a well-drained place and a ventilating chimney of some sort attached to an opening in the top of it. The barrel is first covered with leaves or straw and then with a layer of earth. After the vegetables have been placed within, the open or "head" end is closed with boards and a sufficient amount of earth banked up over these boards to cover them entirely. If now a layer of straw, leaves, or cornstalks is placed over the earth at the head end, this earth will freeze less solidly and it will be easier to open the pit during the winter. The covering of earth on the top of the barrel should be thick enough *not to freeze through;* 3 to 6 inches of earth, or even more, should be used, according to the severity of the winter. The readiness with which supplies can be obtained from the barrel pit makes it especially suited to the needs of a small family.

Earthen storage pits. These are simply piles of vegetables covered with straw or leaves and soil. Venti-

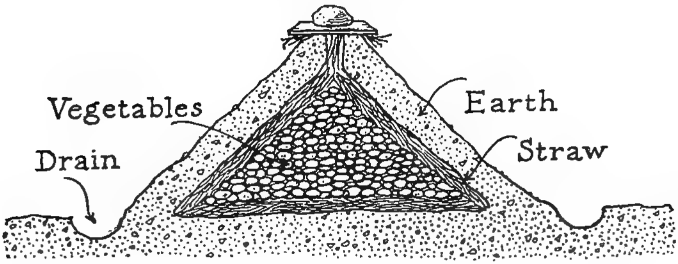

FIG. 186. Cross-section of an earthen storage pit. (Adapted from drawing in Farmer's Bulletin 936, U. S. D. A.)

lation is provided by allowing a large bunch of straw to extend up through the covering of earth at the center of the pit. A board or flat stone is laid over this to shed the water. Vegetables keep well when thus stored, but they are not easily removed unless the entire pit is emptied. Several small pits with different sorts of vegetables in each may be built and emptied one at a time during the winter as the contents are needed.

Storage in banks of earth. If located on a well-drained site, a bank of earth is excellent for the storage of cabbage. The plants are pulled out by the roots and laid, heads down, in rows of two or three abreast. Then a layer of leaves or straw is placed about the heads, and over this a layer of earth a few inches thick is banked up, leaving the roots and part of the stems exposed to the air. As colder weather approaches, more earth may be added; or leaves, straw, or cornstalks may be piled over the bank. Unless the soil freezes very solidly, the cabbages are easily removed one at a time as they are wanted.

Storage in pens. Cabbage, celery, pe-tsai, endive, cauliflower, and Brussels sprouts may be stored in pens. The plants are pulled or dug, leaving some earth on the roots, and reset rather closely in a bed about 3 feet wide. A frame of poles or boards is made about the bed, and boards or poles are laid across the top, completing the pen. Earth is banked about the sides, and the top is covered with straw, leaves, or dirt as the severity of the winter may require. Supplies may be taken from one end as needed.

FIGS. 187 and 188. Storing vegetables in the ground. The cabbages are set head down in a trench and the earth filled in about them. Boxes of root vegetables are placed in a pit. Straw is laid over the top of them, and the earth will then be mounded up over the straw. Vegetables should be stored below the level of the ground only where the soil is loose and well drained.

Use of hotbeds and cold frames for storage. These may be used for storage in the same manner that pens are used. The beds may be emptied by the time they are needed for growing seedlings in the following spring. Late crops of lettuce, celery, and endive may be grown directly in the soil of hotbeds and cold frames. As freezing temperatures occur, the top may be covered and the crop removed as desired.

Storage in attics. Sweet potatoes and squashes may sometimes be stored in an attic near a chimney. Onions may be kept in rather cool attics, as they are not injured by slight freezing, although it is best not to submit them to alternate freezing and thawing. Dry beans and peas may be stored in an attic or even on the pantry shelf.

To provide suitable means for winter storage of home-grown vegetables is thus in most cases a simple matter. The cellar and the attic are usually to be had in the home. Cool rooms are easily made, and once made are permanent. Outdoor barrel pits, banks, and pens also are easily and quickly constructed and afford efficient means of keeping vegetables fresh.

The produce raised on a small garden plot will perhaps be used directly from the garden, but a garden no larger than 4 by 5 rods may yield some produce for storage.

During the winter months fresh vegetables such as beets, carrots, and cabbages are much needed in the diet, and it is during winter that these vegetables usually reach their highest market price. Potatoes, which the small gardener will perhaps buy in the market, may be had cheaper in autumn when bought in bulk. Proper storage in a cool room or in pits will keep these in excellent condition. It pays the gardener to raise crops for storage and to provide simple means of storage, not only for the surplus of the crops he raises, but for such staple vegetables as he does not raise but can buy to advantage in bulk during early autumn.

Questions

In what two ways does the garden serve the table? Why are crops maturing in summer subject to waste? How can such waste be avoided? Give five principal rules applying to the storage of vegetables.

Why is a cellar containing a furnace unsuited to the storage of most vegetables ? How can a cool storage room be made in a cellar? What vegetables may be stored in such a room? What vegetables do not keep well in such a room, and where may they be stored?

How is a barrel storage pit made and used? How are earthen storage pits made? What is their disadvantage? How may cabbage be stored in banks of earth? What vegetables may be stored in pens and how are such pens made? How may hotbeds and cold frames be used for storage?

In what ways is storage for winter use profitable?

Things to Do and Observe

To observe how the various vegetables "keep" under the conditions of storage which you give them. Watch carefully the vegetables you have stored, and if potatoes, carrots, and beets soon shrivel, try to determine the cause, and then take measures to remedy this defect in your storage system or conditions. If the vegetables start to grow, find whether this is caused by too high a temperature or too much light. If they rot to any great extent, try to determine whether they need better ventilation or a lower temperature. Be sure to remember just which remedy was the most effective in each case, so that you can provide the best conditions for storage next year.

APPENDIX

EARLIEST PLANTING DATES

Safe dates for planting vegetable seeds and seedlings in the open in Zones A, B, and C. (See Figure 88.)

Crop	Zone A	Zone B	Zone C
Cabbage	Jan. 1–Feb. 1	Feb. 1–Feb. 15	Feb. 15–Mar. 1
Collard	"	"	"
Garlic	"	"	"
Lettuce — leaf	"	"	"
Onion — sets	"	"	"
Pea — smooth	"	"	"
Potato — Irish	"	"	"
Radish	"	"	"
Turnip	"	"	"
Mustard	Feb. 1–Feb. 15	Feb. 15–Mar. 1	Mar. 1–Mar. 15
Onion — seed	"	"	"
Parsley	"	"	"
Parsnip	"	"	"
Pea — wrinkled	"	"	"
Artichoke — Jerusalem	"	"	"
Asparagus	(Not grown)	"	"
Beet	Feb. 1–Feb. 15	"	"
Brussels sprouts	"	"	"
Carrot	"	"	"
Cauliflower	"	"	"
Celery	"	"	"
Chard	"	"	"
Lettuce — head	"	"	"
Rhubarb	(Not grown)	(Not grown)	"
Salsify	Feb. 1–Feb. 15	Feb. 15–Mar. 1	"
Spinach	"	"	"
Bean — snap	Feb. 15–Mar. 1	Mar. 1–Mar. 15	Mar. 15–Mar. 30
Corn — sweet	"	"	"
Bean — Lima	Mar. 1–Mar. 15	Mar. 15–Apr. 1	Apr. 1–Apr. 15
Cucumber	"	"	"
Eggplant	"	"	"
Melons	"	"	"
Okra	"	"	"
Pumpkin	"	"	"
Potato — Sweet	"	"	"
Squash	"	"	"
Tomato	"	"	"

EARLIEST PLANTING DATES — *Continued*

Safe dates for planting vegetable seeds and seedlings in the open in Zones D, E, F, and G. (See Figure 88.)

Zone D	Zone E	Zone F	Zone G
Mar. 1–Mar. 15	Mar. 15–Apr. 15	Apr. 15–May 1	May 1–May 15
"	"	(Not grown)	(Not grown)
"	"	Apr. 15–May 1	May 1–May 15
"	"	"	"
"	"	"	"
"	"	"	"
"	"	"	"
"	"	"	"
"	"	"	"
Mar. 15–Apr. 15	Apr. 15–May 1	May 1–May 15	May 15–June 1
"	"	"	"
"	"	"	"
"	"	"	"
"	"	"	"
Mar. 15–Apr. 1	Apr. 1–May 1	"	"
"	"	"	"
"	"	"	"
"	"	"	"
"	"	"	"
"	"	"	"
"	"	"	"
"	"	"	"
"	"	"	"
"	"	"	"
"	"	"	"
"	"	"	"
Apr. 1–Apr. 15	Apr. 15–May 1	May 1–May 15	May 15–June 1
"	"	"	"
Apr. 15–May 1	May 1–May 15	May 15–June 1	June 1–June 15
"	"	"	"
"	"	"	"
"	"	"	"
"	"	"	"
"	"	"	"
"	"	(Not grown)	(Not grown)
"	"	May 15–June 1	June 1–June 15
"	"	"	"

LATEST PLANTING DATES

Latest safe dates for planting vegetable seeds in the open in the North, based on the average date of the first killing frost. (See Figure 89.) Only one planting is made of vegetables for which no dates are given.

Crop	Zone C	Zone D	Zone E	Zone F	Zone G	Period Necessary for Maturity
Bean:						
Bush	Sept. 15	Sept. 1	Aug. 15	Aug. 1	July 15	40 to 65 days
Bush Lima	"	Aug. 15	Aug. 1	July 15	—	70 to 90 days
Pole Lima	"	Aug. 1	July 15	July 1	—	80 to 120 days
Beet	"	Sept. 1	Aug. 15	Aug. 1	July 15	60 to 80 days
Cabbage, late	"	Aug. 15	July 15	July 1	June 15	90 to 130 days
Carrot	"	"	"	"	"	70 to 100 days
Cauliflower	Oct. 1	"	"	"	"	100 to 130 days
Celery	Sept. 15	Sept. 1	Aug. 1	July 1	June 1	100 to 150 days
Collard	"	"	"	—	—	100 to 120 days
Corn, sweet	Aug. 30	Aug. 15	July 30	July 15	July 1	60 to 100 days
Cucumber	"	"	"	"	"	60 to 80 days
Eggplant	July 15	July 1	June 15	June 1	—	100 to 140 days
Kale	Nov. 1	Oct. 1	Sept. 15	Sept. 1	Aug. 15	90 to 120 days
Lettuce	"	Oct. 15	Oct. 1	Sept. 15	Sept. 1	60 to 90 days
Melon:						
Muskmelon	June 15	June 1	May 15	May 1	—	120 to 150 days
Watermelon	July 1	July 1	June 15	—	—	100 to 120 days
Okra	July 15	"	"	June 1	—	90 to 140 days
Onion:						
Seed	June 15	June 1	May 15	May 1	Apr. 15	130 to 150 days
Sets	July 15	July 1	June 15	June 1	May 15	60 to 120 days
Parsley	Nov. 1	Oct. 1	Sept. 1	Aug. 1	July 1	90 to 120 days
Parsnip	July 15	June 1	—	—	—	125 to 160 days
Peas	Nov. 1	Oct. 1	Sept. 1	Aug. 1	July 15	40 to 80 days
Pepper	July 15	July 1	June 15	June 1	—	100 to 140 days
Pumpkin	"	"	"	"	—	"
Potato:						
Irish	Aug. 15	Aug. 1	July 15	July 1	June 15	80 to 140 days
Sweet	"	July 15	June 15	May 1	—	140 to 160 days
Radish	Oct. 15	Oct. 1	Sept. 15	Sept. 1	Aug. 15	20 to 140 days
Salsify	June 15	June 1	—	—	—	120 to 180 days
Spinach	Oct. 15	Oct. 1	Sept. 1	Aug. 15	Aug. 1	30 to 60 days
Squash:						
Bush	Aug. 15	Aug. 1	July 15	July 1	June 15	60 to 80 days
Vine	July 15	July 1	June 15	June 1	—	120 to 160 days
Tomato	Aug. 15	July 15	July 1	June 15	—	80 to 125 days
Turnip	Oct. 15	Oct. 1	Sept. 1	Aug. 1	July 15	60 to 80 days

INDEX

The special discussion of a subject begins on the page that is printed in **bold-face** type. Thus the special discussion of "Asparagus" begins on page **282**. A star (*) after a number indicates that an illustration of the subject is to be found on the page referred to.