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Nebraska Plant Disease 4-H Club Manual : Extension Circular 19-01-2

John L. Weihing

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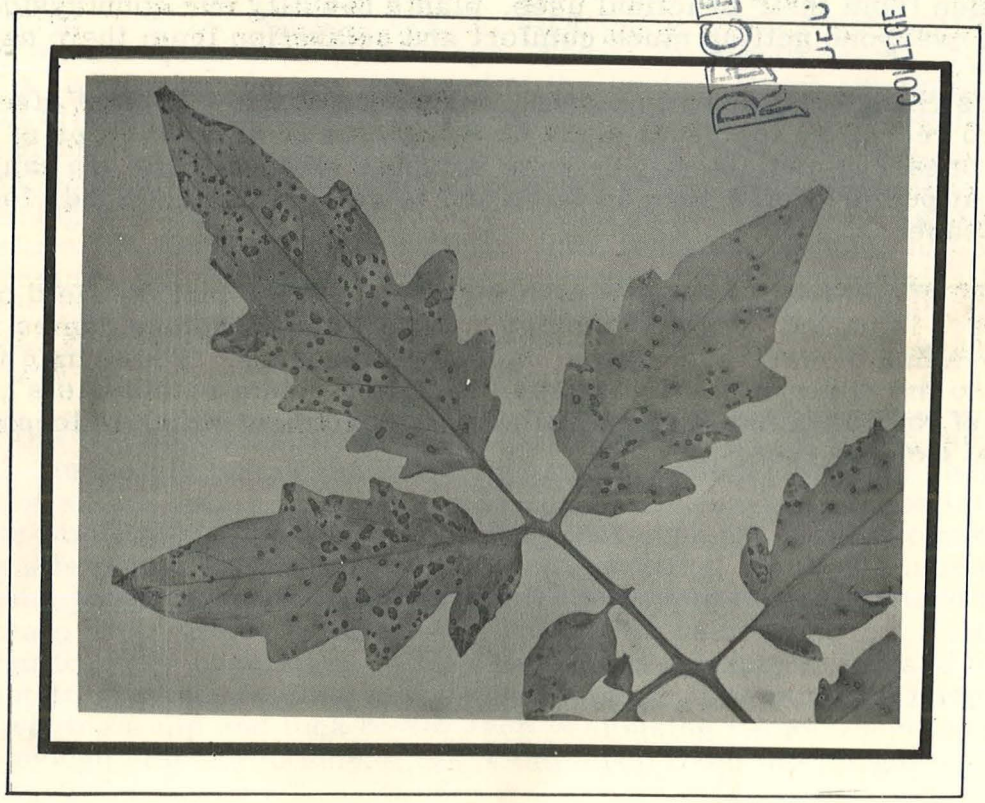
Nebraska Plant Disease

4-H CLUB MANUAL



EXTENSION SERVICE
UNIVERSITY OF NEBRASKA COLLEGE OF AGRICULTURE
AND U. S. DEPARTMENT OF AGRICULTURE
COOPERATING
W. V. LAMBERT, DIRECTOR

PURPOSE OF THE 4-H PLANT DISEASE CLUB

Plants are of great importance to everyone. Just think of the things you use or eat and see if they do not come from some plant. Everything that is made from wood, much of our cloth, coal, oil, gasoline, paper, and most foods come from plants. Aside from their practical uses, plants beautify our countryside and our homes with everyone getting much comfort and relaxation from their natural beauty.

Diseases change and destroy plants. Members of the 4-H plant disease club will learn to recognize the usual signs or symptoms of several types of disease, to collect, preserve and classify disease samples or specimens, to exhibit these specimens at public events such as fairs and to demonstrate methods for control of plant disease.

It may be of interest to the 4-H club member to know that the field of study of plant diseases is called "Plant Pathology". The word pathology comes from Greek; "pathos" meaning disease and "logos" meaning discourse. Those men who devote their lives to the study of plant diseases are called "plant pathologists". The University of Nebraska has a Plant Pathology department which is located on the Agricultural College Campus.

NEBRASKA PLANT DISEASE 4-H CLUB MANUAL

John L. Weihing

Little did Longfellow realize, as he wrote the lines

"Under the spreading chestnut tree
The village smithy stands"

that in a short span of 30 years (1904-1934) chestnut trees would ne nearly gone in the United States -- a tree that grew everywhere in the forests of eastern United States in grandfather's day -- a tree which his grandchildren hear of or read of, but never see. Why? What happened? The answer -- a disease that found its way into American from Asia and spread swiftly, attacking and killing every chestnut tree in its path.

In a 1952 issue of a national magazine there e pictures of a French town in which all the people were sick with a terrible ness. Many of them died. What caused this dreadful sickness? The answer -- bread which had been made from grain containing "ergot". What is ergot? Ergot is a small black, hard, sausage-shaped body which forms in place of a rye, wheat, or barley kernel following the entrance of a certain fungus into the head of the grain. Ergot poisoning is so terrible it is almost beyond description. As the disease progresses the blood stops circulating in fingers and toes, and sometimes in the ears and nose. In some cases, nerves of the body are affected. Finally death comes. We can hardly imagine the human suffering and alarm that must have occurred in the middle ages in Europe where epidemics of ergotism often struck. Just imagine! France had 9 epidemics in the 17th century and 7 in the 18th century; Germany had 11 epidemics in the 16th century, 10 in the 17th, 21 in the 18th and 15 in the 19th century. And even today, with the great knowledge of this disease which has been learned through scientific studies, it still strikes certain people of the world.

Here in the United States there are many Irish people. Why did their ancestors come here? Hunger is one of the major reasons -- hunger brought about by the destruction of entire potato crops in the 1840's by the fungus disease late blight. This disease struck with such speed and fury that even the most promising fields were within a few days nothing but a blackened, rotting, stinking mass of vines and tubers. In the years from 1845 to 1860 a million people died in Ireland as a direct result of potato crop failures, and during this same period one and a half million people moved to other countries. This disease did not stay in Ireland but rapidly spread to potato growing regions all over the world. The potato farmer has ever since been waging a nip and tuck battle each year using various methods of control developed through science to defend the potato crop from late blight's attacks.

Looking through the leaves of history from the time of man's first writings to the present shows us the great effect that plant diseases have always had on individuals, communities, states, nations, and even the world. The above stories are only three in many examples. Now let us come home and see what has happened and is happening right here in Nebraska. It was only in 1946 that a new disease of oats, Victoria blight, moved into eastern Nebraska flattening and ruining our best varieties. In a few years this disease swept across the state as far west as the panhandle. But fortunately, varieties not hurt by Victoria blight were quickly available and had replaced the diseased ones.

In 1951, rain was abundant and the Nebraska farmer looked for a big wheat crop. Nature, however, didn't let it be that way. The welcome moisture was also the welcome mat for certain diseases such as scab, bacterial blight and root rot of wheat, which left the eastern Nebraska farmer only half a crop of poor quality, disease ridden grain. Also, in that year gardeners lost most of the tomato crop by a leaf killing disease, Septoria leaf spot.

And so, on and on it goes. Each year plant diseases destroy the farmer's crops, the gardener's vegetables, the homemaker's flowers, the trees, shrubs, and lawns which beautify our homes; and sometimes even bring about human illness and loss of livestock by poisoning foods.

But really, need plant diseases be so certain to come? Cannot they be prevented from destroying our crops and ornamentals? These two questions cannot be answered by simply a yes or a no. Many diseases can be controlled or prevented but there are some which still dodge the scientist's efforts to understand them. Nevertheless, it is up to each of us to realize that we have always with us many unseen competitors for our foodstuff and many destroyers of our ornamental plants. Through proper understanding of ways that diseases develop in plants and with the proper methods of prevention and control, a great majority of them can be successfully combatted.

CAUSES OF PLANT DISEASES

Whenever someone becomes sick with the flu or a sore throat we usually think of them as having become infected with some "germs". We know there are many different kinds of disease producing germs, the small pox germs, the pneumonia germs, the mump germs and the many others.

Plants become sick from germs too but not from the same ones that make humans or livestock sick. They have their own germs and a very great many of them too. When these germs get into a plant they may cause parts or maybe the whole plant to die. Whenever this happens the plant is referred to as "diseased". The germs are usually called "causal organisms".

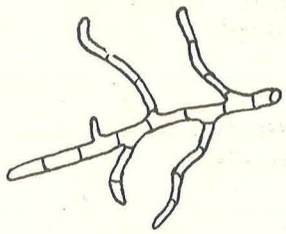
Most germs can be seen with the aid of the microscope. When one looks at them through the microscope he finds that they are of different sizes and shapes. Actually many are found to be tiny plant-like structures producing an abundant amount of seed. These tiny plants do not, however, have the green material like the common plants we know.

Those germs which can be seen with a microscope are classified into two groups, the "fungi" and the "bacteria". Although the 4-H club member may never have the opportunity to see these organisms through a microscope, nevertheless a description and discussion of them is given so that he will be able to better understand plant diseases.

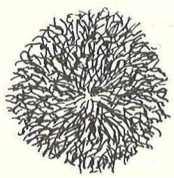
There is still another group of disease-producing germs besides the fungi and the bacteria called the "viruses". Viruses are so small that they cannot be seen with the aid of any microscope. We are all aware of polio in humans. That disease is caused by a virus. There are many other virus diseases of humans. Plants have their virus diseases too. One of the more common virus diseases of plants in Nebraska is "mosaic" in wheat.

The Fungi

Vegetative characteristics - The fungi are actually tiny, thread-like microscopic plants. They are more commonly called molds. Everyone is familiar with molds. Molds frequently spoil our bread or jam or other foodstuff, and are also commonly seen on dead decaying matter such as leaves, wet hay, etc.



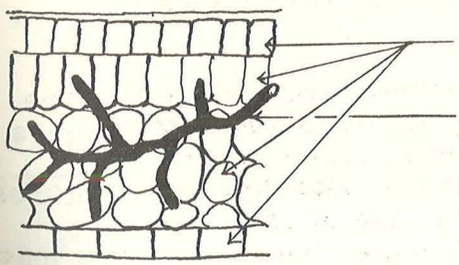
- an individual thread-like, branching strand of a fungus (greatly magnified)



- a mass of entwined fungal threads producing a soft, sponge-like mat.

Figure 1. Illustrations of Vegetative characteristics of the fungus plant. The fungal strands continue to grow longer as long as there is available food and moisture and the weather is favorable for growth. Consequently they form a dense mat.

Parasitic fungi - There are thousands of different kinds of fungi. The majority of them feed on dead matter aiding in its decay. Think of what it would be like of all the cornstalks, straw, roots, and wood suddenly stopped decaying because of the lack of fungi. From this we can see that these tiny plants are really very helpful to us. However, thre are a few of the fungi that are able to feed on living green plants causing much damage and possibly death to the plants. (Fig. 2) Those fungi that do are called "parasitic" or a "fungus parasite".



- plant cells of a leaf

- a fungus growing in, through and feeding on the plant cells causing them to die.

Figure 2. Illustration of a fungus living in a plant tissue eventually causing it to die.

Fungus seed - The fungi produce seeds which are called "spores". The size and shapes of spores differ greatly among the various fungi just as each kind of green plant produces a characteristically shaped seed. Most fungi have the capacity to produce tremendous numbers of spores.

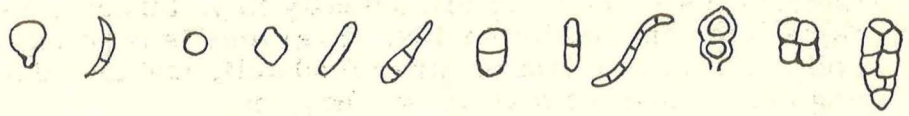
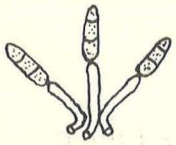


Figure 3. Diagram showing a few of the various shapes of fungus spores that one might see on looking through a microscope at different fungi.

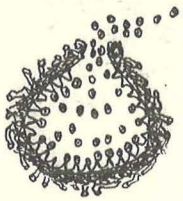
Spores are produced in various ways among the many different fungi. Some are borne at the tips of the thread-like strands, some are produced inside the strands and sometimes special structures arise from the strands and bear spores.

- spores being borne atop a special structure arising from a fungal strand.



- spores being borne at the tips of fungal strands.

- spores being borne on a branch-like structure arising from a fungal strand.



- spores being produced in a sac-like structure that has been formed from a mass of the fungal strands.

Figure 4. A few examples of different kinds of spore production among fungi. (All illustrations greatly magnified)

Methods of spore distribution - The spores may be distributed from place to place in many different ways. Wind frequently carries spores great distances. Sometimes, spores will be carried accidently on farm machinery, insects, animals, and man. Plant parts such as seed, roots, corms, bulbs, stems, leaves, and flowers oftentimes become contaminated with spores of parasitic fungi. In the case of some fungi they may be distributed while in the "vegetative state". For example, the fungus plant may be living inside a tuber, seed or a green plant which is being transported from one area to another.

Spore germination and infection - When a spore germinates it produces a thread-like strand which may act as an infection element. (Fig. 5) The infection elements of certain fungi are capable of penetrating into a plant directly but those of many must enter either through the plant's breathing pores (stomates) or through wounds. (Fig. 6) Plants have numerous microscopic breathing pores distributed over their surfaces.

Once the fungal infection strant becomes established inside the plant, numerous strands start growing and feeding on the plant tissues. (Fig. 2) The invaded tissues gradually die as the fungus parasite feeds on them.

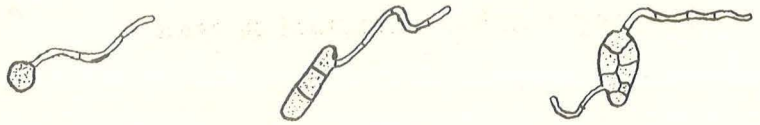
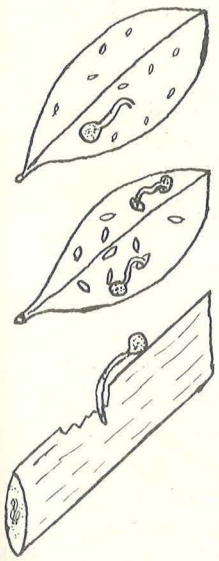


Figure 5. Illustrations of spore germination.

Methods of overwintering by fungi - During the winter months when all the plants have either died or have become dormant the plant parasitic fungi must have some way of remaining alive. Certain ones produce weather-resistant spores that will germinate the following spring. Some fungi do not have the capacity to produce such spores and must survive by other means.



- entrance of the infection element directly through the surface of the plant.

- entrance of the infection element through the plant's breathing pores (stomates).

- entrance of the infection element through a wound.

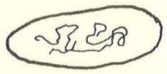
Figure 6. Illustrations of methods by which spore infection elements may enter a plant.

For instance, certain disease-producing fungi invade potato tubers, flower bulbs, corms and rhizomes. These structures are stored at above-freezing temperatures during the winter and the fungi remain alive during the storage. In the spring after the tubers, corms, bulbs and rhizomes are planted and start growing, the fungi also start growing.

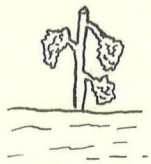
In some cases the fungus does not die out when the plant parts upon which it has been living dies. Instead it is as capable of feeding on the dead material as well as on living tissues. Such fungi may remain alive during the winter in the old dead infected plant parts. Next spring the fungus becomes active, starts growing and producing spores.

In some instances, disease-producing fungi are killed out entirely during the winter but are carried into Nebraska each season by the prevailing southerly winds.

- by forming weather resistant spores



- by living fungal stands in stored tuber, bulbs, etc.



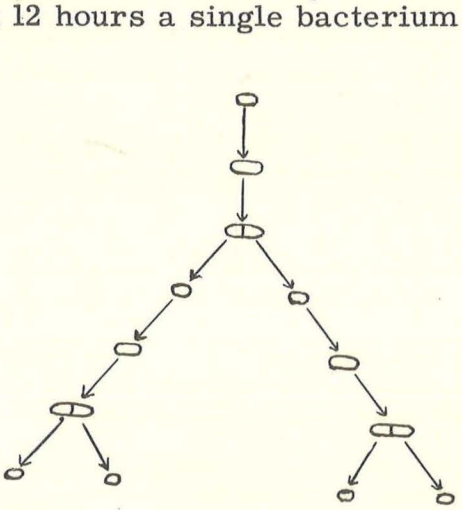
- by remaining alive in old infected plant material.

Figure 7. Several means by which fungi are capable of surviving the winter.

Influence of temperature and moisture - Temperature and moisture greatly influence the development of fungus parasites. Moisture is necessary, in most cases, for spore germination and infection establishment. Temperature regulates the rapidity of growth of the fungus. Some fungi grow best at high temperatures whereas others are favored by low temperatures. The varied responses by the different fungi to various moisture and temperature levels aids in explaining why fungus parasites are not constant from year to year in kind or intensity.

The Bacteria

Vegetative and reproductive characteristics - The bacteria are the simplest forms of plants. The individual bacterium consists of only a single cell within which all the functions of life are carried out. Reproduction is accomplished simply by the division of the cell into two equal parts. These latter two cells grow to a certain size and then they divide. This process continues as long as sufficient food and moisture is available. Redivision may vary from 20 minutes to several hours. This method of multiplication is very efficient in building up tremendous populations. In 12 hours a single bacterium could produce 47, 240, 884, 736 descendants.



- a single bacterium
- grows
- begins division
- divides into two bacteria
- they grow
- they begin division
- they divide into four bacteria

Figure 8. Diagram illustrating how bacteria grow and multiply.

Methods of invading plants - Most bacteria are very helpful to mankind. Many of them feed on dead organic matter aiding in its decay. Some, however, are capable of feeding on green plants thus producing a disease. Bacteria are not able to penetrate directly into plants. They enter the plants through natural openings such as the plants. breathing pores or through wounds or during the feeding of an insect carrying parasitic bacteria or from infected seed.

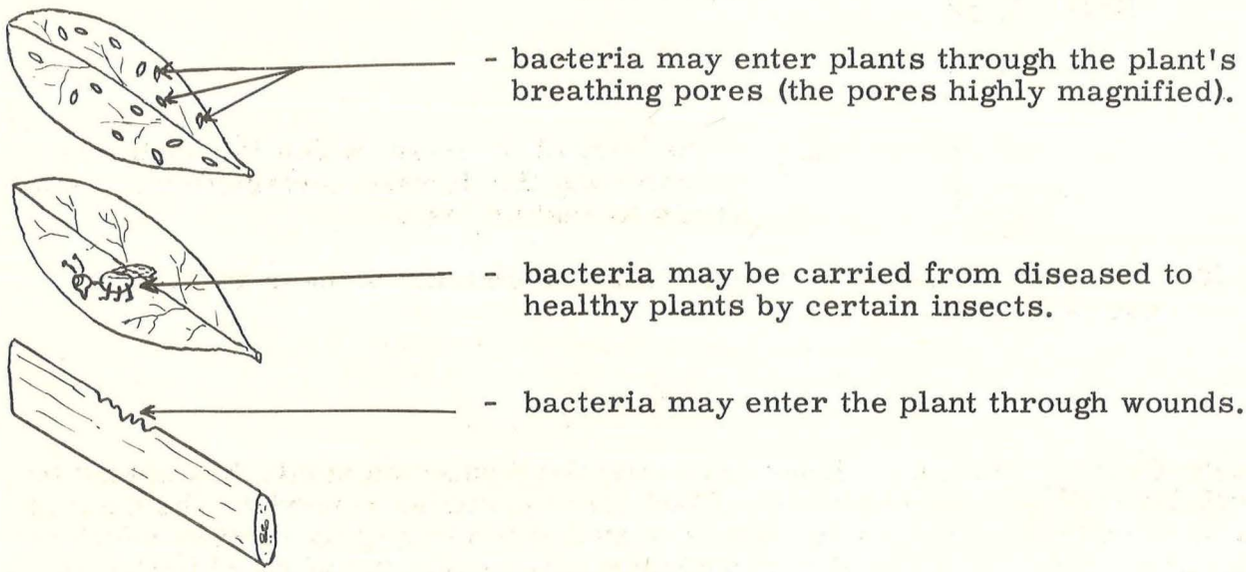


Figure 9. Diagrams illustrating how parasitic bacteria get into plants.

Methods of distribution - The plant disease bacteria do not produce spores as do the fungi. The individual bacteria are quickly killed under dry conditions. They can remain alive while being carried short distances by wind and rain but they are not capable of remaining alive while being carried great distances. Other methods of distributing bacteria besides wind are by insects, farm machinery, animals and man accidentally carrying bacteria from diseased to healthy plants. Also, certain bacteria may remain alive in infected seed or storage organs such as potato tubers, flower bulbs, etc.

Effect of moisture - Excessive moisture favors the establishment and development of many bacterial diseases. Bacteria are generally more dependent upon excessive moisture than fungi.

Effect of temperature - Temperature influences bacterial growth with certain bacteria being favored by high temperatures while others may be most active at low temperatures.

Methods of overwintering - There are several ways by which bacteria might live from season to season: 1) in old dead infected plant parts, 2) in storage organs such as potato tubers and flower bulbs, 3) in the soil, and 4) occasionally in the body of an insect which is capable of transmitting the disease - producing bacteria.

- in old dead infected plant parts

- in infected storage organs such as potato

- in the soil

- in the body of an insect which is capable of transmitting the disease bacteria from diseased plants to healthy ones.

Figure 10. Illustrations of various methods by which plant disease bacteria may overwinter.

The Viruses

Unique Characteristics - Viruses are infective bodies so small they cannot be seen with the ordinary microscopes. Plant virus particles reproduce themselves when in a suitable plant but no one has ever succeeded in getting them to multiply when out of a plant. By scientific procedures, pure solutions of virus particles can be obtained. These solutions are chemical in nature. Actually viruses appear to be on the borderline of living and non-living matter.

Methods of infection - Viruses can infect only when placed in direct contact with living elements of a cell. (Green plants are made up of millions of cells.) This may occur in several different ways. 1) The immediate contamination of fresh wounds with virus will bring about infection. 2) Certain insects when feeding in a virus infected plant obtain some of the virus. When they move to a healthy plant and start feeding they may inject some of the virus particles into living plant cells thus starting infection. 3) The grafting of virus infected tissues to healthy stocks will cause transmission of the virus to the healthy stock.

Methods of distribution - The principal means of distribution of viruses in nature is by insects. Only certain insects are capable of transmitting certain viruses. Virus particles are not blown through the air causing infection in distant places as are some fungi and bacteria. Some viruses are spread through grafts (matural or artificial) and some by accidental contamination of wounds during cultural operations.

Symptom expression - Usually a virus is able to infect from several to many kinds of plants. In certain kinds of plants they may cause an expression of symptoms while in others symptoms may be entirely lacking. Also, temperature may influence the kind of symptoms expressed.

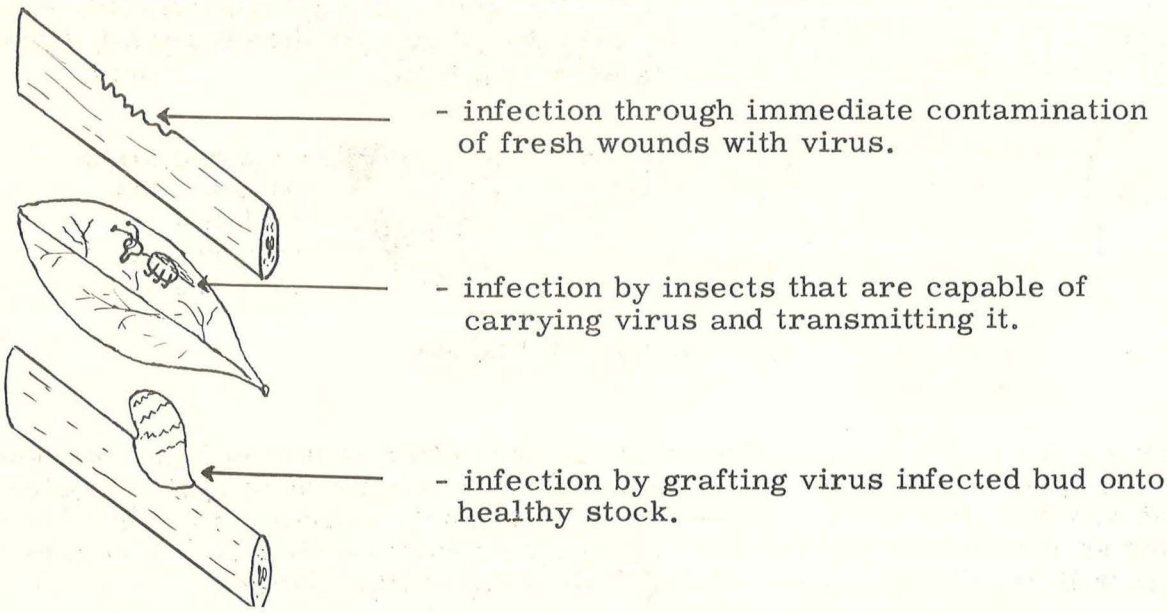


Figure 11. Diagram illustrating the principal ways virus infection may be accomplished.

Methods of overwintering - Many viruses survive from season to season in perennial plants, some in storage organs (potato tuber, flower bulbs, etc.), a few are known to be able to live in seed, and there are known cases where the virus may be soil-borne.

TYPES OF DISEASES

When a person becomes ill he usually has certain characteristic symptoms such as becoming pale, getting dizzy and weak, maybe having a swelling of certain glands, etc. These symptoms aids the doctor in the diagnosis of the disease so that he may prescribe a treatment. When plants become ill they too usually have particular types of symptoms such as spotting of the leaves, blighting of the buds, or a stem rot. The type of treatment for control of the disease may sometimes be determined by the type of the disease symptoms.

Plant diseases generally can be classified by use of the disease symptoms. Following is a discussion and illustrations of the various types of symptoms which shall be used as units of classification by the 4-H club member.

Basal stem rot - The main stem of the plant becomes soft and watery near the ground level. Finally the stem becomes so rotten and weak that the plant falls over, wilts and dies.

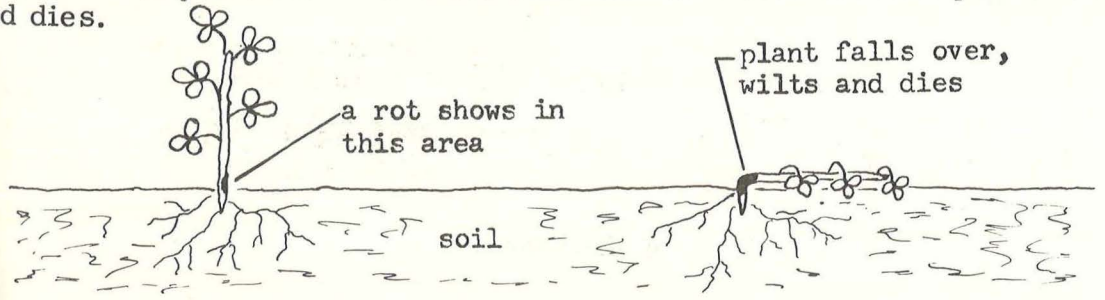
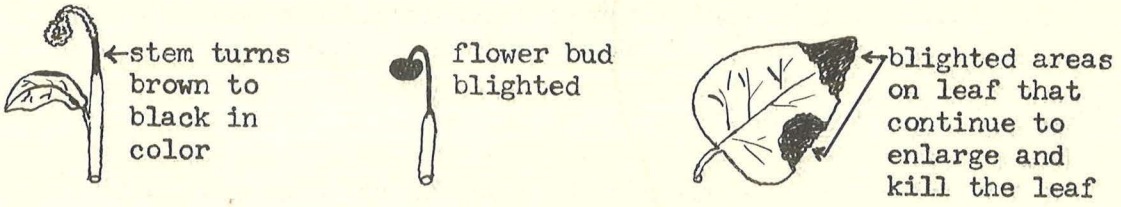


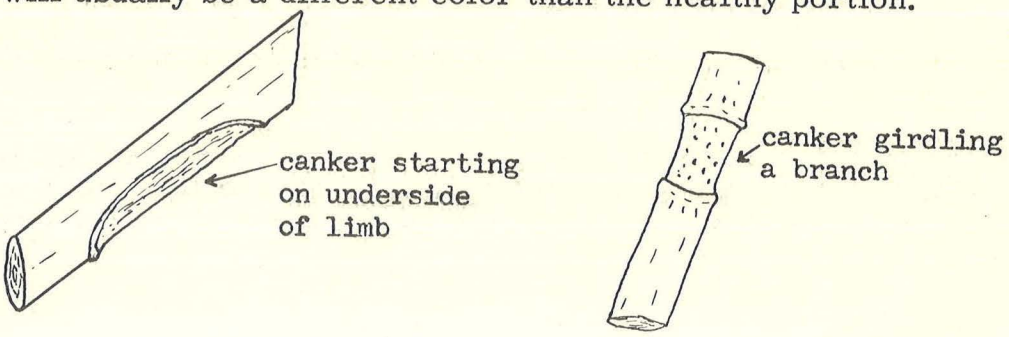
Illustration of basal stem rot

Blights - These are often confused with leaf spots. Blights usually kill a portion of a plant, such as an entire leaf, or several leaves, or the blossoms, or the stem. No definite small spots are formed as with leaf spots.



Illustrations of blights

Cankers - A canker is a localized disease area often resulting from an open wound and usually on a woody structure. Starting as a definite dead spot it gradually enlarges and may girdle the cane, stem or tree trunk, killing the water-conducting tissues so that the most prominent symptoms become a dieback. The bark in the canker will usually be a different color than the healthy portion.



Illustrations of cankers

Corm, Bulb, and Rhizome diseases

Soft rot - The corm, bulb, or rhizome turns into a soft, wet, mushy, oftentimes vile-smelling, rotten mass.

Dry rot - The underground part gradually decays. The rotted tissues remain relatively dry.

Damping-off - This disease strikes seedlings that have just emerged from the ground. They are attacked at or near the soil line by organisms which cause the stem in that area to quickly rot away. The plant falls over, wilts and dies within a few hours.

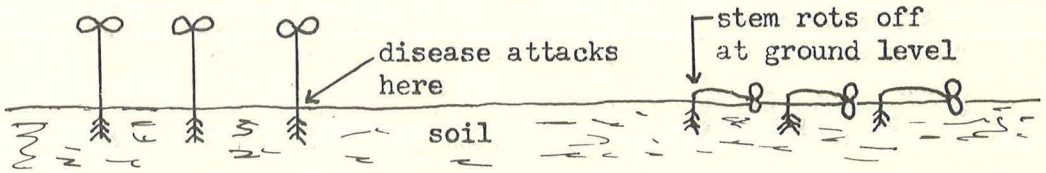
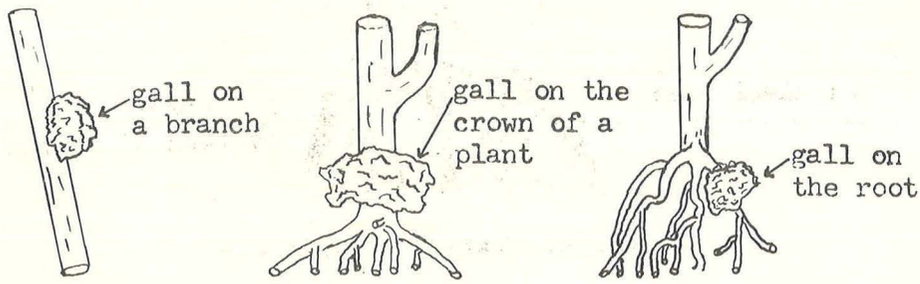


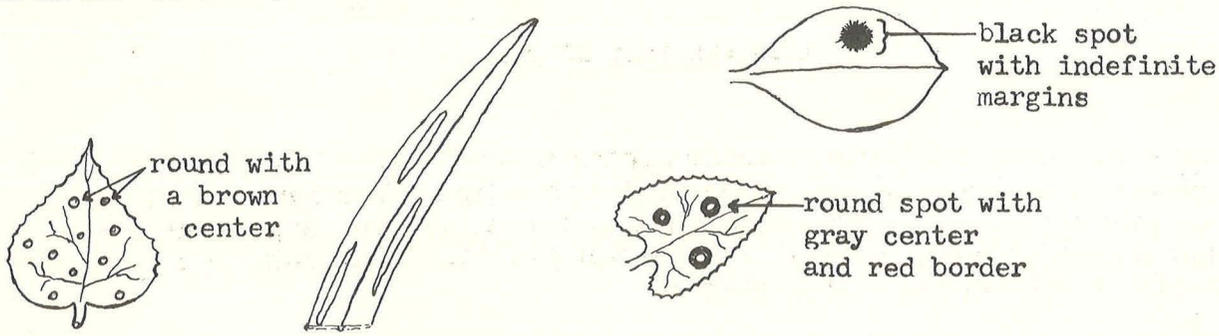
Illustration of damping-off

Galls - Occasionally cauliflower-like swelling or growths will appear on the canes and roots of cane fruits such as raspberries. Such swellings are also often seen on limbs and branches and even leaf-stems of trees.



Illustrations of galls

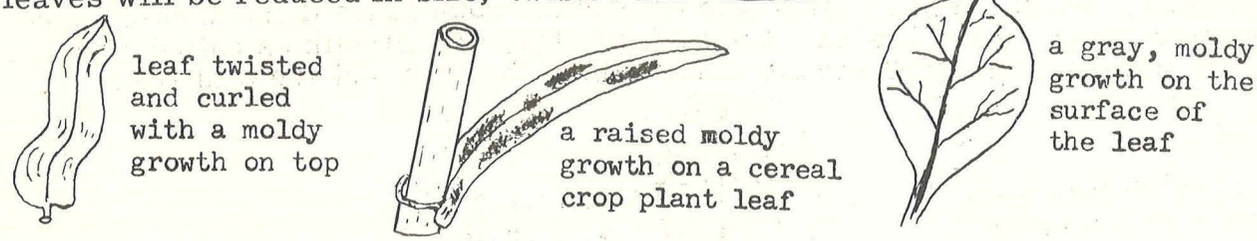
Leaf Spots - (A spot or spots occur on the leaves) These may vary from a spot 1/8 inch or more in diameter. When several spots appear on a leaf, the leaf is frequently killed. The spots on the leaves may be round, irregular in shape, or in the form of streaks. The leaf tissues in the centers of the spots are dead and usually brown to grey in color although sometimes they are brightly colored. The edges of the spots next to the living green tissues may be very sharp and definite whereas sometimes they may be quite indefinite. The dead tissues may or may not drop out leaving a hole in the leaf.



Illustrations of various kinds of leaf spots

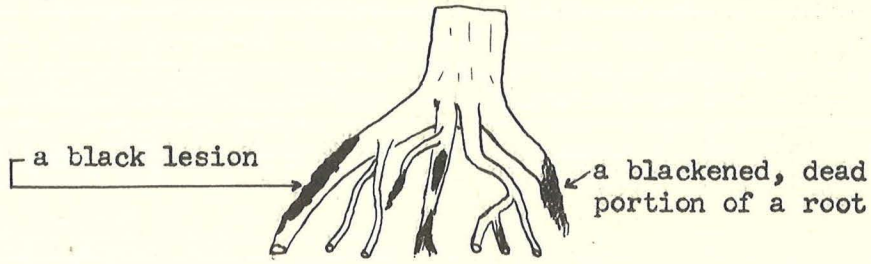
Mosaic - The green color of the leaves changes to a light and dark green mottle. Oftentimes there will be a crinkling and puckering of the leaves associated with the mottling. Virus diseases most frequently cause the mosaic type diseases.

Mildew - This disease is very common on most ornamental plants, many garden plants, and some grain crops. It shows as a greyish, moldy growth on the leaf, usually on the upper surface, and is a result of the organism growing on the surface of the plant. The mildew gradually causes leaves to turn yellow and die. Frequently the leaves will be reduced in size, twisted and curled.



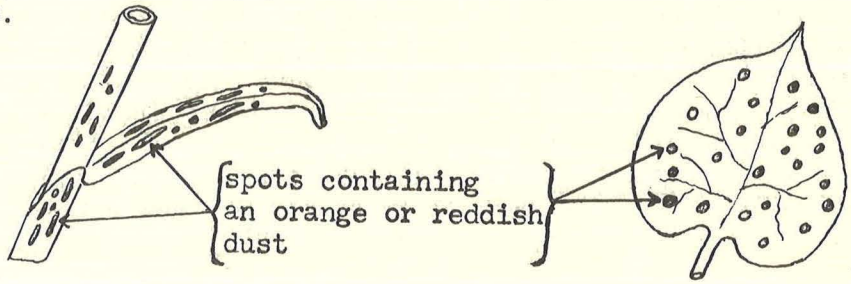
Illustrations of mildew

Root rots - These cause brown to black spots on the roots. In some cases the roots may be completely destroyed. Root rots may be found on any plant



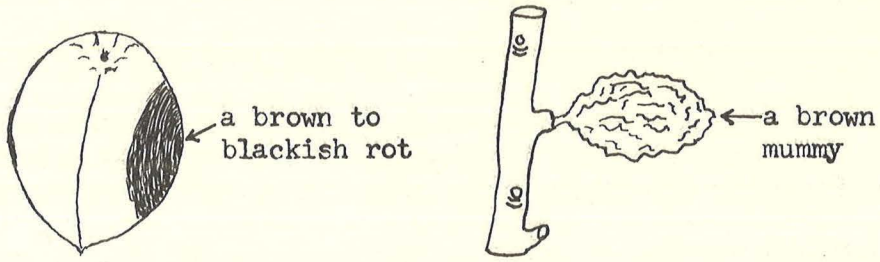
An illustration of root rot

Rust - Rust appears as a reddish or orange powder in round to elongated spots occurring principally on the leaves. Occasionally it is found on other parts of the plant. When one rubs a finger over the rusted area, the rust powder will readily collect on the finger. This rusty powder is made up of hundreds of seeds (spores) of the rust fungus.



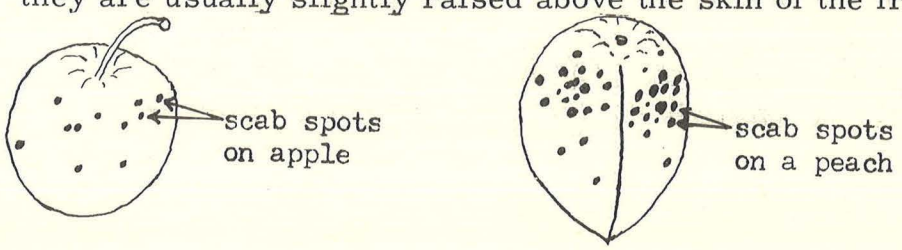
Illustrations of rust

Fruit rots - Brown to black rotten areas appear on the fruit. These rotted areas may continue to enlarge until the entire fruit has rotted. The rotten fruits gradually shrivel up into mummies. Oftentimes these rotten fruits will hang on the tree throughout the entire winter. During warm wet weather these mummies may become covered with a light-brown moldy growth.



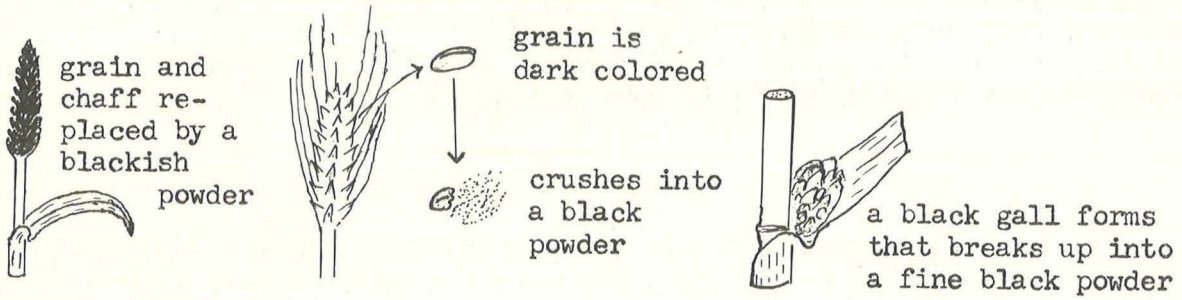
Illustrations of fruit rots

Scab or fruit spots - Black spots appear on the surface of the fruit, spoiling its appearance. No rot is associated with the spots. Sometimes these dark-colored spots also appear on the leaves. On the fruits they are oftentimes called scab since they are usually slightly raised above the skin of the fruit and are scab-like.



Illustrations of scab on fruit

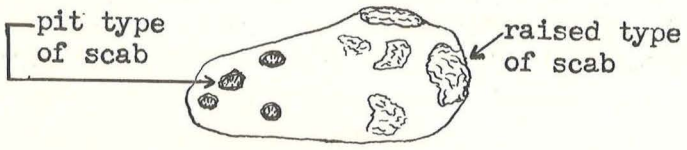
Smut - Smut appears as a black sooty powder. On small grain crops such as wheat, oats or barley smut destroys the entire head, or just the grain, with these plant parts becoming a mass of the black powder. On corn it causes large galls that are filled with a black powder. Smut may also be found on other plants, however, it is chiefly a disease of small grains and grasses.



Illustrations of smut on plants

Tuber diseases -

Scab or scurf - Scab-like, round, brownish lesions appear on the surface of tubers. Sometimes these lesions are raised above the skin of the tuber; sometimes they form a pit in the tuber. The spots do not produce a rot but spoil the appearance of the product.



Illustrations of scab

Soft rots - The tuber is destroyed by a soft, usually vile-smelling, rot that normally progresses very rapidly.

Wilts - The plants wilt down as though they were suffering from drouth although there is plenty of water. Eventually the plants dry up and die. There are several causes for wilts. Root rots, basal stem rots, and various other root and stem infections will cause plant wilts.

Yellows - The plant gradually looses its deep green color and becomes yellow in appearance. Oftentimes plants affected with yellows become severely stunted and distorted.

METHODS OF DISEASE CONTROL

There is no one method which will control all plant disease organisms. Disease organisms vary tremendously in their life habits and the plant organs which they might attack. As has already been discussed, many of the diseases are caused by

living organisms, the fungi and bacteria. Chemical poisons will kill these organisms. Some chemicals can be diluted and sprayed on plants without injuring them but still the chemical will kill the disease organisms. This type of treatment may be very effective in controlling the "leaf spot" or "blight" types of diseases. But what about the root rot or tuber types of diseases? Spraying the plants will not give protection from them. Thus it can be readily seen that before starting to control a disease it is necessary to find out a few basic facts regarding the disease such as what part of the plant does it affect. Following is a discussion of various control methods and various types of diseases which they may be used against.

Seed Treatment

Purpose - Seed treatment has a two-fold purpose, 1) to kill the disease organisms which might be on the seed and, 2) to protect the seed after it is planted from being attacked by disease organisms that might be in the soil. Let us discuss these two sources of diseases separately.

There are quite a few diseases which may be carried on the seed. Probably the most familiar diseases of this type are the smuts of grain. The spores of the smut organisms of oats and sorghums and covered smuts of wheat and barley are carried on the seed. The spores of the scab fungus of wheat and barley also are carried on the seed. When the seed is treated with a proper seed treatment compound the spores of these disease organisms are killed and the plants freed from any likely infection.

Living in the soil are thousands of different kinds of microorganisms. Most of these microorganisms are very beneficial to mankind, but occasionally, if weather conditions are right, some will attack and destroy the seeds we plant. Treating the seed will protect the seed against the soil parasites by killing them when they come in contact with the seed. It is, therefore, advisable to treat all seeds before planting.

Spraying or Dusting The Plants

Organisms that cause leaf spot and blight diseases are frequently controlled by spraying or dusting with a chemical poison. The chemical poisons used for plant disease control are referred to as "fungicides". There are numerous kinds of fungicides on the market. However, we will mention only those which are easily obtainable and which will serve the purpose of controlling diseases.

Facts About Spraying and Dusting

The spray or dust fungicides act only as protectants and will not cure already existing infection. When the proper chemical is sprayed upon the plant, a thin layer of poison collects over its surface. When spores of disease organisms that are being carried in the air land on the plant they are killed by the layer of poison. If an infection has taken place before a plant is sprayed, this infection will not be killed out after spraying because the chemical poison is not taken inside of the plant where the infection exists.

In spraying or dusting one should make certain that the plants receive a very thorough coverage with the fungicide. The underside of the leaves need protection

as well as the upper. Plant areas missed by the spray or dust are likely to become infected.

The time that one should start spraying or dusting depends on what disease or diseases one is trying to control. With fruit tree diseases one must start very early and carry on a spring and summer spray schedule. As for vegetable and flower diseases, spraying is usually started when the first signs of the disease appears and the plants resprayed periodically every 10 to 14 days thereafter. One must respray because the plants are growing and the new growth does not have any protective chemical. Also the protective chemical weathers away.

The question "which are the best, sprays or dusts?" is frequently asked by gardeners. Usually one receives better results from sprays, particularly in those seasons when the disease being controlled is severe. Better plant coverage is obtained with the sprays. There are some diseases however, such as the rusts and mildews for which dusting will give very good control.

Control of the leaf spots and blights of vegetables and flowers - The fungicides containing copper are very good for the control of many of the leaf spot and blights of vegetables and flowers. The oldest, and probably still the best, is Bordeaux mixture. This mixture can be purchased already prepared or one can obtain the chemicals and make it himself. The preparation of a standard Bordeaux mixture may be done as follows: 1) Dissolve 4 tablespoonsful of copper sulfate in a cupful of water. 2) Dissolve 6 tablespoonsful of spray (hydrated) lime in another cupful of water. 3) Add these dissolved materials to one gallon of water and mix well. 4) Strain this solution through a fine screen or coarse cloth into the spray tank.

There are many copper containing fungicides on the market. The commercial names of these products are too numerous to mention. On each package there is a list of "active ingredients". Check this list on the packaged fungicides in the drug store or seed stores for copper. If the product contains copper, it probably is satisfactory for use in the vegetable or flower garden. Be sure and follow the manufacturers recommendations on amounts to be applied.

There are some relatively new spray compounds that give excellent control of garden diseases. They are Ferbam, Nabam, Zineb and Ziram. Packaged fungicides which have one of these compounds appearing in its list of "active ingredients" which is always found on the outside of the package, will probably be satisfactory for use in the garden.

Control of fruit tree diseases

Wettable sulfur in general does a very good job in controlling the leaf and fruit diseases of fruit trees. Suggested fruit tree spray schedules can be obtained from the county agricultural agents office.

Control of rusts and Mildews

Dusting the plants well with dusting sulfur will give adequate control of these two types of diseases.

Sanitation

As has been pointed out before under the discussion on fungi and bacteria, disease organisms frequently live on the old dead infected material throughout the winter until

the next spring. In such instances the old dead material acts as a reservoir for the disease from season to season. Under field conditions the old plant material may be plowed under and in this way reduce the reservoir of diseased material. In the back-yard garden the old vines and leaves can be gathered and burned. Burning the material is the surest way of killing the disease. Although burning is an excellent practice for disease control, such a practice will in time deplete soil of organic matter which is very important for good crop production. Therefore, when one burns the old plant material, he should replenish the soil organic material by spading or plowing in an abundance of leaves or straw or some other type of organic matter into the soil.

In fruit trees one often sees old dried up fruits hanging on the branches throughout the winter. Beneath the trees there is usually an abundance of old fallen fruit. Both the fruits on the ground and those hanging on the trees may be harboring disease organisms. These fruits should be gathered and buried in a pit.

Control of Weeds

It is a very desirable practice to keep the field, garden or ornamental plantings free from weeds since weeds can be carriers of disease. Many of the viruses which cause diseases of economic plants are capable of infecting weeds. Frequently the viruses infect perennial weeds but do not kill them. Both the plant and the virus remain alive indefinitely. Insects may feed on the weed, then feed on a vegetable plant or flower and in the feeding process transmit the virus.

Resistant Varieties

Planting disease resistant varieties can be the most economical means of controlling a disease. Plant breeders have for many years been breeding various crop and ornamental plants for resistance to particularly severe diseases. Excellent resistance to certain diseases has been obtained with some plants. If it is known that a plant variety has resistance to a common disease and the variety is adapted to the area in which it is to be planted, it should be considered for planting.

Information regarding disease resistance of various crop varieties can be obtained at the county agricultural agents office. Commercial seed concerns handling vegetable and ornamental plants usually print excellent seed catalogues which contain information on the disease resistant qualities, if any, of the various varieties.

Control of Insects

There are many instances in which insects are spreaders and carriers of plant diseases. The spread of most virus diseases is dependent upon insects. The viruses, however, do not have a monopoly on this phenomona because numerous bacterial and fungus diseases are also distributed by insects. The control of the plant feeding insects can certainly in some instances produce a two-fold effect: 1) eliminating insect damage and 2) controlling a disease.

Rotation of Plantings

Generally those parasites which feed upon, let us say, beans will increase if beans are grown continuously in the same field for several years. But what happens when one

plants corn in that field following beans? The bean parasites are not capable of living on the corn and they die of starvation. Field crop rotation or rotation in the vegetable or flower garden is a very important way of keeping many diseases from reaching disastrous proportions.

Source of Seed

Some disease organisms can be carried inside the seed and seed treatment will not eliminate them. A very common example of such a disease is bacterial blight of beans. One of the principal ways of controlling this disease is to plant disease-free seed. Such seed can be obtained from areas in Idaho where the disease does not occur. If seed is obtained from areas where the bacterial blight developed, blight would be an extremely serious problem. This example illustrates how important seed source can be with certain diseases.

Sterilization of Soil

Soil sterilization is a laborious and expensive practice. It cannot be done on an extensive scale. In greenhouses and cold frames, however, where plantings on a small amount of ground yields high income, soil sterilization is often practiced to rid it of any soil-borne parasites.

Soil can be sterilized with steam, heat, or chemicals. The use of chemicals is the most common method since special equipment is necessary for steam or heat or both. The chemicals most commonly used are formaldehyde and chloropicrin (tear gas). For detailed instructions on soil sterilization consult your county agricultural agent.

COLLECTION AND PRESERVATION OF DISEASED SPECIMENS

The collecting, preserving and then classifying of diseased specimens is one of the best methods by which one may acquaint himself with plant diseases. Through collection of diseases one sees the great range of types of diseases that prevail about us every day during the growing season. Such a project aids us in appreciating the fact that plant diseases can do damage. One should not confine his collection of diseases to only plants of economic importance. Diseases appearing on weeds should also be collected and classified since oftentimes it is from a weed that a field crop, vegetable, fruit tree, or ornamental gets a disease.

Plant Foliage

Satisfactory preservation of plant parts such as leaves, succulent stems, and some flowers can usually be done by allowing them to dry in a plant press. The most satisfactory type of press is made by using large sheets of blotting paper, at least 8 inches by 11 inches. These can be placed one on top of another on a flat surface with a board on top. Leaves may be pressed merely by laying them flat between two of the blotters. Thick stems will need to be split so that they will dry. A weight should be placed on the board to press the plants flat and to facilitate drying.

A plant press that may be carried into the field can be made by using a board above and below the stack of blotters. Pressure is applied by running a strap around the press. A flat slat frame is usually used in preferance to a solid board.

A catalogue or magazine with rough or dull paper is also satisfactory for drying plants. The slick sheets should not be used.

As material is collected and placed in a plant press, the date, location, name of the plant, and name of the collector should be recorded and kept with the specimen.

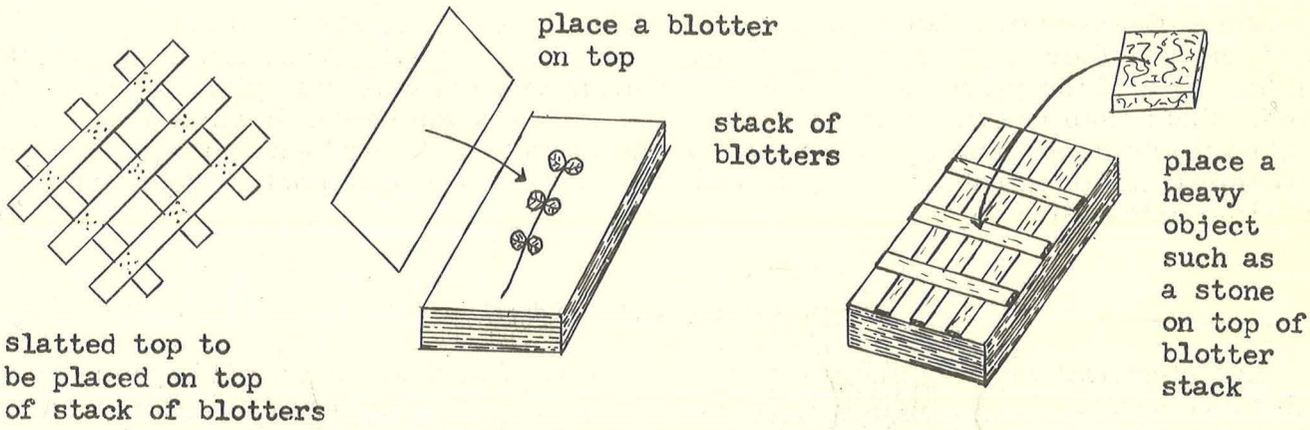


Figure 12. Diagrams illustrating a plant press.

Fleshy Fruits, Tubers, Corms, etc.

Fleshy fruits, such as apples, peaches, etc., and potato tubers cannot be dryed in a plant press. They may be preserved by placing them in a jar containing formaldehyde or a 95 per cent alcohol solution or even by placing them in rubbing alcohol. Alcohol solutions tend to remove the color from the specimens. Special formula for making more permanent mounts, with less loss of color, will be furnished upon request to the the Plant Pathology Department, Nebraska College of Agriculture, Lincoln, Nebraska.

Woody Specimens

Disease specimens from trees and woody shrubs do not need to be given any special treatment for preservation. The taking of a diseased section of a limb, shoot, cane, or stem and permitting it to dry naturally is sufficient.

Seeds

Seeds will keep indefinitely without any preparation in boxes, bottles or jars, but should be watched for weevils which might eat them. Para-dichlorobenzene crystals may be placed in the container with the seeds to control insects.