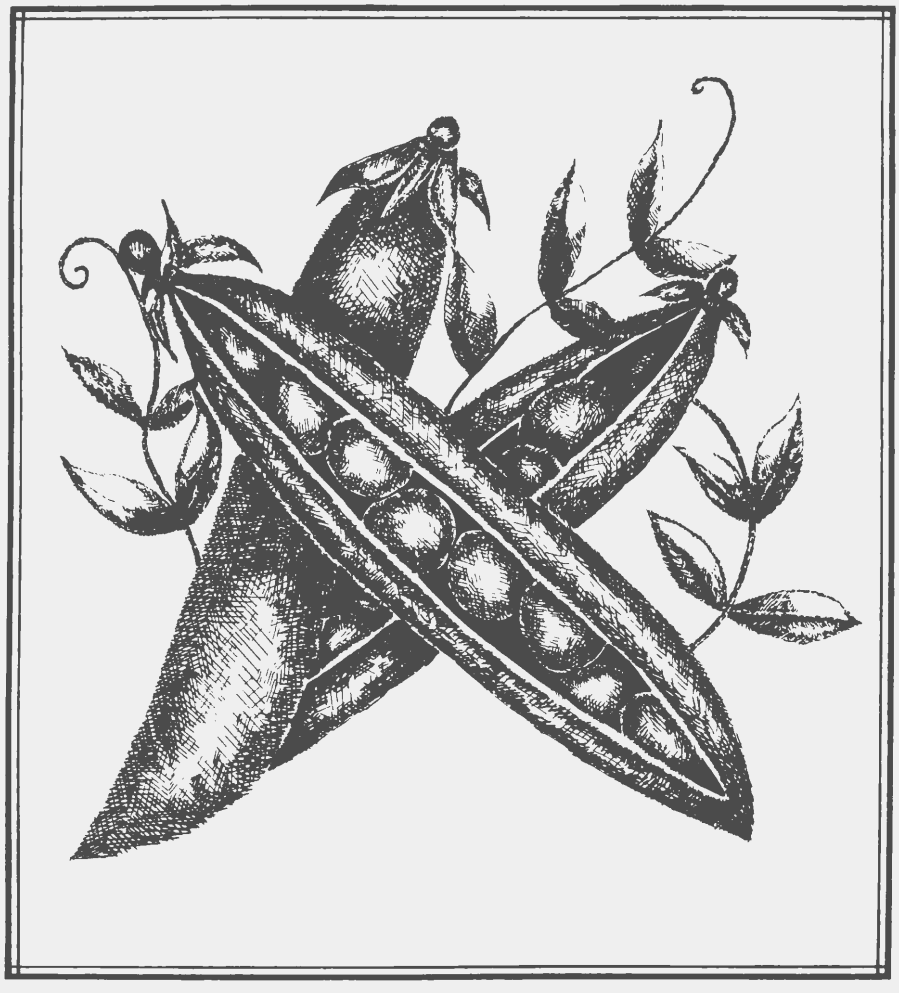
ORGANIC GARDENING

Extension Bulletin 0648



Cooperative Extension College of Agriculture Washington State University

Organic Gardening

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by *Art Antonelli*, Extension Entomologist; *Ralph Byther*, Extension Plant Pathologist; *Al Halvorson*, Extension Soil Scientist; *Robert Thornton*, Extension Horticulturist; *Bruce Barritt*, Research Horticulturist; Washington State University

One definition of organic gardening is that it is the enrichment of a garden soil with naturally occurring plant foods and the control of garden pests (insects, diseases, and weeds) by environmental, cultural, or natural chemical methods. Animal manures, composts, and crop rotation are agricultural tools gardeners can employ to provide well-balanced fertilization for their plants. Likewise, controlling plant diseases and insects does not always mean the use of fungicides or insecticides. Plant pests can be held in check with cultural practices.*

Adding Organic Materials to the Soil

Natural soils differ in an infinite variety of characteristics. The scientific classification of soils recognizes 800-1,000 individual kinds in the state of Washington, each different from others in color, depth, size, and arrangement of the individual sand, silt, and clay particles, mineral composition, content of organic matter, etc.

Soil organic matter or humus is the dark-brown-to-black substance in the surface layer of soil made up of organic compounds resulting from decomposition of vegetative and animal matter. Manure, composts, and other organic residues improve the soil's physical condition or structure, the friability (ease of working), permeability to water, aeration (allowing increased oxygen supply to roots), and nitrogen retention. Organic matter also aids in conservation of plant foods and moisture, energy, and nutrient availability for soil microorganism populations.

Use of well-rotted farm manure provides a method of maintaining soil organic matter. Dry and pulverized manures also serve the purpose well and are usually more readily available in towns and cities, as are processed sewage sludge, spent hops (waste hops from beer) or composts made from tree leaves, lawn clippings, garden refuse, and other organic residues. When other organic materials are not available, a fast growing green manure crop, preferably oats, barley, or rye may be grown and worked into the soil before the heading stage of growth.

Buying or hauling manures, waste hay, and the like from barns, feedlots, or fields may add some new kinds of weeds to the garden. Some commercially composted materials and processed manures available on the market are treated to kill weed seeds. Mixing undecayed coarse plant materials such as strawy manure, corn stalks, waste hay, straw, or cover crops into the soil uniformly can be a problem to gardeners without power tools. Rotary cultivators and discs can do the job. Putting coarse material through a power grinder-shredder makes it much easier to work into the soil with hand tools, but grinder-shredders do not work well with wet, limp materials. Where a grinder-shredder is not available, a lawn mower can be used to cut up tender materials.

This publication is a revision of the work originally prepared by Arlen Davison, Henry Tabor, and H. S. Telford.

*You can obtain other information on garden preparation from WSU Extension Bulletin 0422, *Home Gardens*.

Manures

Manures provide plant food. Poultry or rabbit droppings taken from beneath roosts or hutches are high in nitrogen. They may actually "burn" plant roots if used too generously. Most manures are short on phosphorus in comparison to nitrogen and potassium; most Western and Central Washington soils need phosphorus.

Table 1 gives the percentage of total nutrient content in animal and poultry excretment as eliminated (undiluted). The value of manure as plant food depends on the extent to which it has been diluted or leached by water and the proportion of bedding, such as straw, sawdust, or shavings that is mixed in. The kind of storage and the length of storage also affect manure quality.

Table 1. Total nutrient percentage of animal excrement, as eliminated (undiluted).

Livestock	Water	N	P_2O_5	K_2O
Poultry	75	1.5	1.2	0.80
Cow	83	0.60	0.15	0.45
Hog*	86	0.50	0.35	0.40
Horse	78	0.70	0.25	0.55
Sheep	68	0.95	0.35	1.00

*If hog manure is used, be careful! Pigs carry parasitic roundworms that can be transmitted to humans. The parasite's eggs are passed in the feces and can be picked up by humans (particularly small children who put their hands in their mouths) from the soil. Be sure your source is from "parasite free" pigs.

Well-rotted or aged manures can be spread on the soil in the late winter or early spring and dug in or mixed with soil as soon as the soil is in workable condition. Be sure not to dig too close to trees, shrubs, and perennials and cut off feeder roots. Spread and work fresh manure into the soil in the fall.

Commercial Organic Fertilizers

If manures are unavailable in your area, you may wish to purchase commercially prepared organic fertilizers. Base your selection on whether your soil needs primarily nitrogen, phosphorus, or potassium and on the ability of the fertiliezr to release the nutrients into available forms at such a rate that the crop's nutrient needs can be continuously met throughout the growing season. This is of special importance with respect to nitrogen since this nutrient is required in large amounts by plants. Whenever possible, obtain one of the quicker-acting organic fertilizers for your nitrogen supply, such as blood meal, dried blood, or fish scraps (or liquid fish). Keep in mind that plant nutrients in even these materials are not immediately available. When the soil is cold in the spring, and the decomposition process is slow, very little plant food will be released and crops may suffer a temporary shortage of nitrogen. As the soil warms up, decomposition speeds up and consequently, also nutrient release.

If wood ashes are used in large quantity, salt injury can result. Ashes should be applied at a rate not to exceed 15 pounds per 1,000 square feet of area. Mix ashes thoroughly into the top 4 to 6 inches of soil.

Table 2 shows what materials provide various nutrients.

Table 2. Percentage of nutrients from various organic fertilizers.

Material	Nitrogen Sources N% (total)
Cottonseed meal	6
Blood meal	15
Fish scrap	4-6
Dried meat meal	9-11
Dried blood	8-14
Soybean meal	7
Animal tankage*	7-8
Material	**Phosphorus Sources P_2O_5% (total)**
Rock phosphate	25-30 total, (only 2-3 available)
Bone meal (raw)	22
Bone meal (steamed)	23-30
Animal tankage*	10
Material	**Potassium Sources K_2O% (total)**
Greensand	7
Kelpmeal†	5
Granite fines	3
Corn cob ash‡	4-8
Wood ashes‡	5-7

*A good N + P source

†May also contain considerable sodium.

‡Contains all nutrients except N.

Soil pH

The general appearance of the growing crop can be used as one guide in evaluating soil pH. If the soil fertility level is adequately provided for, if moisture and other growth factors are satisfactory but still a few or all of the garden crops are not growing well, then the problem may be an undesirable soil pH. A soil test for pH should be made at this point.

You can have the acidity of your soil measured by a soil testing laboratory. (For details on how to properly take soil samples, see EC 0387, *Taking Routine Soil Samples for Cultivated Crops*, available at your county Extension office.)

A pH of 7.0 is neutral, a pH above 7.0 is alkaline, while a pH below 7.0 is acidic. Most vegetables grow best on a slightly acid soil in the range of pH 6.0-6.8. Minor elements, such as manganese and boron, are not likely to be a problem if the pH is within this range.

If a pH test has been made and the soil pH is between 5.5-6.0, add 30-50 pounds of dolomitic lime or limestone flour per 1,000 square feet. For heavy soils use the higher rate. For a pH 5.0-5.5, make two applications of the above rates—one before plowing and the other before planting. If your soil pH is 4.9 or less, double the rates used for the 5.0-5.5 range. Western Washington residents should use dolomite lime. It contains magnesium as well as calcium. Magnesium is often needed in Western Washington soils. (See table 3.)

Table 3. Lime sources and nutrients.

Materials	$CaCO_3$	$MgCO_3$
	. . . . . %	
Dolomite	50	50
Limestone flour	97	2

Fertilizer Application

No one fertilizer is best for all plants in any location or any plant in all locations. Some general suggestions can be made. You must adjust kinds and amount that will supplement the soil's ability to meet the plant's nutrient needs. Many shrubs, trees, and perennials grow too fast and become too large too quickly. Holding them back may be as much of a problem as getting them to grow. Established trees, shrubs, and perennials that make good growth each year, that have a healthy appearance, and that flower or fruit adequately, are just as well off without fertilizer.

Most annual plants (particularly those that are set out as transplants), perennials (the first season after dividing or starting new plants), and newly planted bulbs will benefit from moderate fertilization at the time they are transplanted or put in the garden. Specific amounts of fertilizer that will be right to apply in all situations cannot be given. Start with moderate amounts where needed and adjust according to your observations of plant response. If your plants are making good growth, have a good color, and flower and fruit well, stay with your present fertilizer program. Your long-range objective should be to build your garden area to a high fertility level and then to maintain fertility through composting and mulches, reducing your reliance on commercial organic fertilizers.

As a general application for flower beds or garden areas, use 4 pounds nitrogen, 10 pounds of phosphorus (P_2O_5), and 6 pounds of potassium (K_2O) per 1,000 square feet. Cut down the amount or proportion of nitrogen if you use it in combination with compost or manures. Step up nitrogen if you use it with uncomposted leaves, strawy material, or sawdust. An exception to the nitrogen rate must be made for tomatoes in Western Washington. Excess nitrogen produces vigorous vine growth and immature, green fruit under cool growing conditions. Therefore, use no more than the equivalent of 1 pound of avaiable nitrogen per 1,000 square feet of area.

To determine the amount to purchase, divide the percentage of available nutrient in the fertilizer material into the number of pounds of nutrient needed. For example, if you need 10 pounds of available phosphate (P_2O_5) per 1,000 square feet and you are using rock phosphate (available P_2O_5 in rock phosphate is about 2%), then divide 10 pounds by 2%. The result is 500 pounds rock phosphate per 1,000 square feet of area. (This rate is based on the assumption that the soil is low in available phosphorus and that the soil has a pH of 6.0 or less.)

How to Buy Organic Materials

The brand name on commercially prepared organic or natural fertilizers may not give any clue as to the nutrients it can provide. As an example, meat meal or tankage provides both nitrogen and phosphorus. Soybean meal provides mainly nitrogen. (See tables 2 and 5 for further details.) Further, there is a wide variation in value due to moisture content, type of storage, and other conditions. Your only alternative to obtain it at a reasonable price is to compare the percent of nitrogen, phosphorus, and potassium among commercial materials.

By Washington State law, all mineral (chemical) fertilizers must have the percentage *available* nutrients listed on the package. (The three major nutrients are nitrogen (N), phosphate (P_2O_5) and potash (K_2O)—always listed in that order.)

Regarding organic fertilizers, the *total* nutrient content is given in percentage (not the available amount). The total percentage of each major nutrient is listed in the same order as for mineral fertilizer. For example, blood meal is listed as 7-10-0: 7% nitrogen (N), 10% phosphate (P_2O_5) and 0% potash (K_2O). When purchasing organic fertilizer, do some comparative shopping—buy on the basis of which one provides the greatest amount of nutrients per dollar of cost. If you are interested in dried blood, the nitrogen percentage can vary from 12%-15% depending on brand. Also, bone meal varies widely in percentages of available phosphorus, largely due to whether steamed or raw.

Composts

Composts can be a good source of humus and plant nutrients and also a good way of getting rid of a lot of plant refuse from the yard or garden. It should be understood, however, that improper composting will not kill many weed seeds, disease organisms, or underground stems or roots of such plants as quackgrass, morning glory, Canada thistle, iris, or bulbs. If you are having disease troubles with certain kinds of plants in your yard, keep those plants out of the compost. Further, be sure not to add nonplant garbage or other kitchen waste to the pile since rotting food attracts rodents.

In structuring your compost pile, the addition of 1 to 2 inches of stable or poultry manure to each layer of crop residue will aid in starting rapid decomposition. If manure is not readily available, add 1 to 2 inches of soil to each layer of residue.

Sewage Sludge

Two different types of sewage sludges are available. digested sludges created by a primary treatment with anaerobic digestion, and activated sludges formed by injection of air. Sewage sludge should be used cautiously because of the possible presence of cadmium (heavy metal), dangerous to humans.

Digested sludge is usually of relatively low quality as a fertilizer compared with products from an activated system.

Dried, activated sludge, properly heat treated, normally commands a good price on fertilizer markets. Digested sludges, on the other hand, are often available without cost or at low price. Activated sludges are widely used as fertilizers for lawns and golf courses. Digested sludges are used as mulches around certain kinds of plants not requiring acid conditions. They are also spaded into flower and vegetable gardens.

Heat-treated sludges are normally safe for use from a sanitary standpoint. Digested sludges, not heat-treated, should be used with some caution. The health departments of several states have issued regulations specifying the conditions under which sludges that are not heat-treated may be used as garden fertilizers.

The total plant food content of sewage sludge is variable. Table 4 shows the range within which most sludges will fall.

Table 4. Total nutrient content of sludge.

	N	P_2O_5	K_2O	pH
		%		
Activated process	5-6	3-7	Under 1	4.5-5.5
Digested process	1-3	1 1/2-4	Under 1 1/2	5.5-7.0

Sawdust

Fir, hemlock, or alder sawdust can be used to mix with garden soils. The sawdust may be used whether fresh or weathered. Fresh sawdust will last longer than old sawdust when used as a mulch and will make soils somewhat lighter or more re-

tentive of moisture when plowed under. Old or rotted sawdust will become humus more readily and is less likely to cause nitrogen deficiency. Cedar bark has proven toxic to some plant seedlings. It breaks down in the soil slowly. Alder sawdust breaks down more quickly in the soil than fir or hemlock. There is evidence that alder sawdust encourages Armillaria, a rot on woody plants, more than does fir or hemlock. When mixing sawdust with soil, it is best not to work in more than 2 inches of sawdust in any one year. It should be mixed thoroughly with 6-8 inches of soil.

A cubic yard of sawdust will cover 300 square feet 1-inch deep. A bushel will cover 15 square feet 1-inch deep.

Whenever a sizable quantity of sawdust is added to soil, extra nitrogen must be applied with it. For each cubic yard of sawdust (300 square feet 1-inch deep) 1 pound of available nitrogen should be added. This can be supplied by animal manure or commercial organic nitrogen fertilizers. Be sure the manure does not contain any sawdust or wood shavings. It is always wise to watch plant growth closely when large quantities of sawdust have been used. Slow-growing plants with small pale-green or yellowish leaves usually need more nitrogen. A side-dressing of blood meal or soybean meal may be necessary during the growing season.

Mulches

Mulching is an excellent method of conserving soil moisture and preventing weed growth while at the same time increasing soil organic matter. Sawdust, straw, old hay, leaves, and grass clippings are the common materials used.

After removing young weed seedlings by cultivating, simply apply 1-2 inches of one of these materials around the plants, being careful not to cover the plant, which would cause delay in growth. Spading under the mulch in the fall will aid the soil organic matter content.

Most of these mulches are stemmy materials high in carbohydrates (cellulose) and low in nitrogen. Soil microorganisms cannot get enough nitrogen from these materials to break them down adequately to humus so they absorb additional nitrogen from soil reserves. In fact, so much soil nitrogen is "tied up" in bacterial action that garden plants next spring will be cut short and experience a nitrogen deficiency, evidenced by yellowing and stunting of growth. This is the most common problem facing users of mulches.

Some organic materials contain substantial amounts of plant food elements whereas others contain very little. Selection of a mulch high in nitrogen content will assist soil microorganisms in decomposition. (See table 5.)

To avoid a nitrogen shortage, use 1 pound of available nitrogen per 1,000 square feet of mulch area when the total nitrogen content of the mulching material drops below 1.3%. You can supply this amount by using a manure (100 pounds of poultry manure or 200 pounds of cow, hog, or steer manure) or an organic fertilizer (15 pounds soybean meal or 7 pounds blood meal). It is important that manures used to avoid a nitrogen shortage do not contain sawdust or wood shavings. Spade the nitrogen source under with the mulch in the fall.

Table 5. Total nutrient content of mulch (dry weight).

Mulch	N	P_2O_5	K_2O
	. . . . %		
Alfalfa hay	2.45	0.50	2.10
Alfalfa straw	1.50	0.30	1.50
Grass hay	1.20	0.35	1.75
Clover hay	2.10	0.50	2.00
Pea vines (green forage)	2.08	0.60	2.00
Oats (green forage)	1.50	0.65	2.20
Rye (green forage)	2.00	0.80	2.80
Wheat (green forage)	2.14	0.20	2.48
Wheat straw	0.50	0.15	0.60

Mulches to protect perennials or the crowns of roses from freezing, must stay fairly loose. Use coarse materials that do not pack. Straw, stemmy hay, or marsh hay is best. Sawdust, shavings, and leaves are used but these settle and pack too much.

For the vegetable garden the use of black plastic or aluminum foil mulch offers the advantages of total weed control, conserving soil moisture, increase in soil temperature, and cleaner fruit. Aluminum foil will help repel aphids. A disadvantage is that the plastic or foil have to be removed by hand after the growing season. Also, they do not supply organic matter.

Plant Disease Control

Some people think that controlling plant diseases always means spraying with chemical pesticides. Quite to the contrary, pesticides are only one of the many techniques and tools used to combat diseases. An organic gardener can use all of the methods available, but must also be willing to put in extra time and effort to accomplish the job. A basic understanding of plant diseases is essential if you are to be successful.

Plant Disease Principles

A plant disease is a process that adversely affects all or part of the functions of a plant. It may also affect plant structures. It is abnormal and harmful in some way.

Plant diseases are generally divided into two groups based on their cause:

1. *Nonparasitic diseases* are induced by some genetic or environmental factor, such as nutient deficiencies, extreme cold or heat, toxic chemicals (air pollutants, weed killers, or too much fertilizer), mechanical injury, or lack of water. These diseases cannot be spread to healthy plants, and their control depends solely on correcting the condition causing the disease. Two-thirds to three-fourths of plant problems are in this group.
2. *Parasitic diseases* are caused by living organisms (pathogens) which derive their food by growing as parasites upon plants. The most common causes of parasitic diseases are fungi, bacteria, viruses, and nematodes. A few seed-producing plants, such as the misletoes, can also cause plant diseases. Only one-fourth to one-third of plant problems are in this group.

Fungi are plants that lack the green coloring (chlorophyll) found in seed-producing plants and, therefore, cannot manufacture their own food. There are between 50,000 and 100,000 different species of fungi of many types and sizes, but not all are harmful. Most are microscopic, but some, such as the mushrooms, are quite large. Most fungi reproduce by spores.

Bacteria are very small one-celled plants that reproduce by simple fission. They divide into two equal halves, each of which becomes a fully developed bacterium.

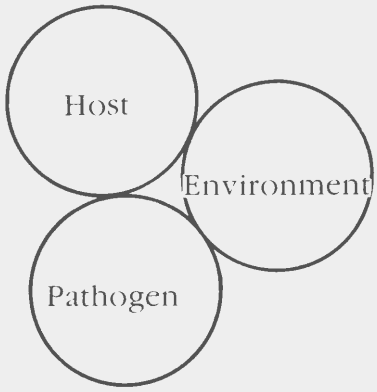
Viruses are so small that they cannot be seen with the ordinary microscope. Many of the viruses that cause plant diseases are transmitted from one plant to another by insects, usually aphids or leafhoppers. Viruses are also very serious problems in plants that are propagated by bulbs, roots, and cuttings, because the virus is easily carried along in the propagating material.

Nematodes are small eel-shaped worms that reproduce by eggs. The number of eggs produced by one female nematode and the number of generations in a season depend on soil temperature. Therefore, nematodes are usually more of a problem in warmer areas of the country. Most nematodes feed on the roots and lower stems of plants, but a few attack the leaves and flowers.

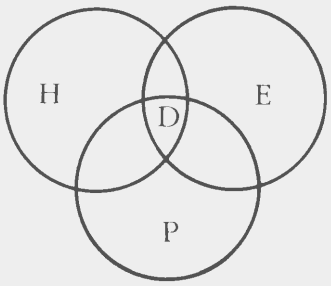
It is helpful to think of a parasitic plant disease as a process involving three factors: a host plant, a pathogen (microorganism), and the environment that affects both. The concept is illustrated in figure 1.

The host plant will have certain characteristics, such as being resistant or susceptible to a particular pathogen. In turn, the pathogen will have characteristics which make it successful or unsuccessful as a cause of disease on the particular host. Environmental factors, such as moisture, temperature, and nutrition affect both the host and the microorganisms that cause disease and play a vital role in the disease development process.

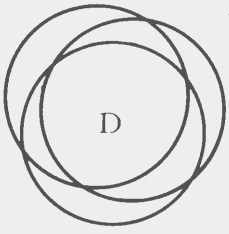
Ingredients for a plant disease epidemic would be a large population of a susceptible crop, an abundance of an aggressive pathogen, and weather and microclimatic conditions around the plants that favor rapid development of the disease. The probable outcome could be changed only by changing the relationship among the three factors—host, pathogen, and enviroment. When you begin to change this relationship, you are attempting to control the plant disease. Your success will depend on many factors, including your understanding of the particular disease and the options open to you.



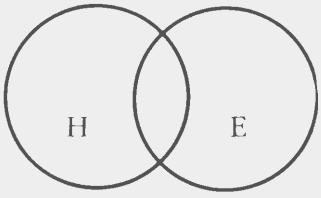
1 No disease.



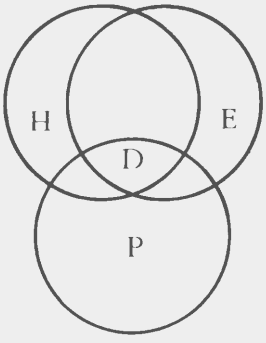
2 Normal combinations of factors—requires no control.



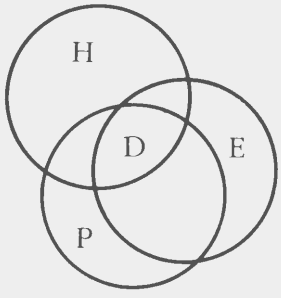
7 Epidemic level—control needed.



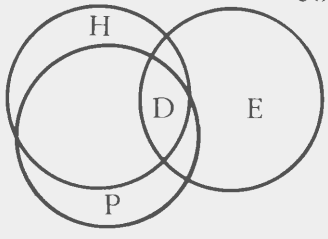
3 Control by exclusion. Prevent introduction of pathogen.



6 Control by eradication. Reduce pathogen population by sanitation, etc.



4 Control by resistance. Planting varieties resistant to disease is the best method of control.



5 Control by protection. Modify the environment with chemicals of cultural practices.

Fig. 1. Three factors of parasitic plant disease and levels of control. The disease (D) is represented in the areas where the circles overlap.

Methods of Combatting Plant Diseases

Attempts to control plant diseases can be frustrating, expensive, and unsuccessful if you do not choose the best method for the particular plant disease. The phrase "plant disease management" is a realistic description because seldom, if ever, do we really completely "eradicate" disease. The incidence and severity of many, but not all, plant diseases can be controlled to where they are not major limiting factors in the production of a crop. As with insects and weed pests, we must battle plant diseases almost every year on many crops.

Exclusion

This process involves controlling a plant disease by preventing the introduction of a pathogen to an area where it is not already present. That area can be a country, state, or an individual garden, or, in some cases, even an area of a garden.

Upon entering this country, and even some states, you may be asked if you are carrying living plants, fruits, vegetables, or plant products. Such inspection, hopefully, is a method of preventing entry of certain insects and disease pests. Washington State has restrictions concerning the introduction of certain plants into this state. When ordering plant materials through catalogs, you may have experienced that your order is not filled but is returned with the indication that these plants cannot be shipped to Washington. For instance, grape plants or cuttings are not permitted to enter the state in order to help protect the grape industry from the introduction of several virus diseases not yet known to be present in Washington.

Individual gardeners should be sure that the plants they put into their own yards are as free from disease as possible. Using certified planting material, when available, is highly recommended. In Washington, certification programs on potatoes, strawberries, raspberries, and fruit trees are effective in controlling virus diseases on these crops. Plants will display a state inpection tag if they qualify for certification.

Eradication

Eradication of a plant disease organism (pathogen) is carried out in a number of ways. Many of these we commonly refer to as "cultural control practices." They include crop rotation and sanitation. In most situations, however, the organism is not completely eradicated but is reduced to a level where significant losses are minimized.

Crop rotation. Rotating crops is as old as agriculture and is based as much on art and superstition, in some cases, as on scientific fact. It is obvious that continuous cropping in one area can perpetuate and build up pathogenic organisms. Crop rotation, however, is not always effective because of the various microorganisms and their different capabilities of survival. A 3- to 5-year rotation is suggested for home gardens. The rotation should include plants from different families. Cabbage, cauliflower, and broccoli, for example, are all related and would not be considered as good choices of sequence in a rotation. Potatoes, corn, cole crops (cabbage, broccoli, turnips, radishes, cauliflower, etc.), legumes (peas and beans), and leafy vegetables would be an example of a more logical sequence.

Sanitation. This can be defined as the removal and destruction of diseased or dead plants or plant parts as soon as the maladies are noticed. It is a common and effective plant disease control technique. A reduction in the population of disease organisms results in less chance for serious disease outbreak. Destruction of volunteer plants, overwintering host plants, infected crop residue, and diseased plants is an example of good sanitation.

Sanitation in handling vegetatively propagated materials is of utmost importance in preventing the spread of virus diseases. Virus-infected plants should be removed and destroyed (roguing). These plants cannot be cured. They act as potential disease sources.

Pruning. Pruning diseased twigs and branches is helpful in controlling diseases such as brown rot and Coryneum blight of stone fruits and anthracnose and European canker of apples. Pruning cuts should be made well below the diseased area (3-6 inches) to be sure that all the diseased tissue is removed. If, in the process of pruning, a cut is made into diseased tissue, the shears should be disinfected before making another cut. Shears can be disinfected by washing with soap and water and swabbing with rubbing alcohol. Shears should also be disinfected when the work on each tree is completed. Trees in need of pruning for disease control should be left until last; this will lessen

the chance of spreading the disease. Destroy pruned-out plant parts.

Fruits of strawberries, raspberries, beans, etc., which are infected with gray mold (*Botrytis*) must be destroyed if this disease is to be kept under control without the use of fungicide sprays. Raking up and destroying leaves infected with apple scab is beneficial in breaking the life cycle of this disease.

Diseased plant materials *should not be composted.* Proper composting (reaching a temperature of 140° F/60° C) will inactivate most disease organisms. Incomplete composting, however, will result in spreading the disease.

Weed control. This can also be important in preventing disease. Certain weeds can act as a source of infectious material. Wild blackberries, for instance, are often infected with virus diseases and the bacterium responsible for crown gall.

Protection

Fungicides are used in disease control to protect the plant from infection; thus, they need to be applied before the plant is diseased. There are only a limited number of situations where fungicides can actually cure a plant once it is diseased. Because the fungus that causes powdery mildew is located on the outside of the plant, it is vulnerable to fungicide sprays after infection has taken place.

For many years it has been known that elemental sulfur has fungicidal properties, and some organic gardners are not opposed to its use. To be used as a fungicide, it must be ground very finely; thus, ordinary sulfur that is used as a fertilizer will not act as an effective fungicide. Sulfur, available as a fungicide, can be applied either as a dust or (mixed with water) applied as a spray. Plant damage can result if it is used when temperatures are above 85° F/29° C.

Copper fungicides are also acceptable to some organic gardners. Historically, Bordeaux mixture (a mixture of copper-sulfate and lime) has been used. It is not widely used today because it needs to be prepared (copper-sulfate and lime mixed together) each time it is used. Fixed coppers (such as Microcop) are used more commonly because of their convenience. If you choose to use any of these fungicides, be sure to follow label directions and precautions and use them only on plants that are indicated on the label.

There are *nonfungicidal* methods to protect plants from disease. These generally involve methods of avoiding situations that favor plant disease development.

Planting site. Choosing the right planting site is important. This involves wide geographic considerations, as well as specific sites in a yard or garden. For example, because of the severe disease problems on apricots, cherries, and peaches (Coryneum blight, brown rot, bacterial canker, and peach leaf curl), the fruits are not easily grown in, nor recommended for, Western Washington. The drier, warmer climate of Eastern Washington is the place to grow these fruits. Growing small fruits offers another example: raspberries require soils with excellent drainage in order to avoid root rot problems. Good winter drainage is as important as summer conditions. In contrast, blueberries tolerate wet soils.

Planting date. Date of planting can also influence disease development. Planting too early, especially pumpkin, squash, etc., can lead to seed rot and damping off of young seedlings. Delaying planting until the soil has warmed allows the young plants to grow faster, and thus avoids rotting organisms. On the other hand, planting peas early avoids the virus disease problems. Aphids, which transmit these viruses from clover-type plants to peas, are not active during the early part of the growing season; thus, the peas avoid infections by developing before exposure to the virus-carrying aphids.

Planting conditions. Good air circulation and light penetration help avoid the humid conditions that promote disease. Overcrowding creates microenvironments conducive to plant disease.

Fertilization. Properly fertilized plants are generally more resistant to disease than those under nutritional stress. Overfertilization, leading to an abundance of soft, luxuriant growth, is also conducive to disease losses.

Moisture. Diseases can also be avoided by proper watering. Overhead irrigation (applying water through sprinklers which wet the leaf surfaces) should be avoided when possible. Applying water directly to the soil surface by digging furrows adjacent to rows or using soaker hoses are

better alternatives. If overhead sprinklers must be used, watering should be done in the morning so that the foliage has a chance to dry before evening. Late afternoon watering allows the foliage to remain continuously wet throughout the night which invites disease. Most infective propagules (fungus spores, etc.) which initiate plant disease require moisture to germinate and cause infection. Thus, cultural practices which help foliage become dry or remain dry aid in control of plant diseases, especially foliar diseases.

Handling. Proper handling before and after harvest can prevent rots from certain diseases. Late blight of potatoes is a good example of a harvest disease. Late blight not only causes a severe foliage disease but also results in a storage rot if the tubers become infected. Tubers are infected during harvest when they contact the fungus that is on the diseased vines. Tuber infection can be prevented if the vines are cut and removed from the area 10-14 days before tubers are harvested. Cut the vines an inch or so below the soil surface. Not only will the tubers not contact the disease, but this 2-week curing period promotes a toughening of the skin which will help prevent wounding during harvest.

Another example of a harevst disease is Botrytis gray mold, which can be responsible for rotting of berries after they have been picked. This postharvest rot can be avoided by picking the berries during cool parts of the day, keeping picked fruit out of the sun, and placing them in cool storage as soon as possible. They should not be washed until they are ready to be consumed or processed, since moist surfaces allow germination of the spores of rotting organisms. This fungus, however, can develop on berries before they are picked.

Acidity. Soil acidity can also influence the development of certain diseases. Potato scab, for instance, is most severe in soils that have a neutral to alkaline pH. Thus, additions of lime, wood ashes, and manure increase the severity of potato scab. Club root of cabbage, and other cole crops, acts in just the opposite manner. Applications of lime have been shown to reduce the severity of this fungus disease.

Genetic Resistance

Purchasing crop varieties that are resistant to one or more pathogens is the most economical and desirable way to avoid disease losses. When selecting varieties for disease resistance, it is important to know whether the disease is a potential problem in your area. For example, apple varieties resistant to fire blight are desirable in Eastern Washington; but, since the disease is essentially never a problem in Western Washington, fire blight resistance is not a criterion for selecting a variety to grow there.

Locating information on disease resistance is often difficult and sometimes impossible. Generally, seed catalogs and other sources will advertise certain varieties as having specific disease resistance. It must be assumed that if this information is not given, the variety is susceptible. A general statement that a variety has good disease and pest resistance should be treated cautiously. The resistance they possess may have no application to the disease problems in your area.

Table 6 contains information sources on variety resistance. Your county Extension office will be able to supply you with the numbered publications. The Northwest Plant Disease Control Handbook can be purchased from the Oregon State University Bookstore, P.O. Box 489, Corvallis, OR 97330. Contact the bookstore for the current price.

Table 6. Information sources about disease-resistant plants.*

Crop	Disease	Information Source
Apple	Scab Powdery Mildew	*Northwest Plant Disease Control Handbook*
Apple (flowering crab)	Scab	*Northwest Plant Disease Control Handbook*
Cherry	Bacterial Canker	*Northwest Plant Disease Control Handbook*
Corn	Smut (head)	*Northwest Plant Disease Control Handbook*
Cucumber	Angular Leaf Spot Powdery Mildew Scab	*Northwest Plant Disease Control Handbook*
Lawn and Turf	Fusarium Patch Red Thread Rust Others	EB 0713, *Diseases of Turf Grass* EB 0482, *Home Lawns*
Lilac	Bacterial Blight	*Northwest Plant Disease Control Handbook*
Pea	Enation Mosaic Wilt	*Northwest Plant Disease Control Handbook*
Potato	Scab Leaf Roll Late Blight	*Northwest Plant Disease Control Handbook* EM 4051, *Potato Scab* EM 2704, *Potato Leaf Roll* EB 0958, *Late Blight of Potato & Tomato*
Pyracantha	Scab	*Northwest Plant Disease Control Handbook*
Raspberry	Powdery Mildew Rust Virus Root Rot	*Northwest Plant Disease Control Handbook* EM 4262, *Root Rots of Raspberry & Strawberry in Home Gardens*

Table 6. (cont'd)

Crop	Disease	Information Source
Rhododendron	Root Rot	*Northwest Plant Disease Control Handbook*
Rose	Black Spot Powdery Mildew Rust	*Northwest Plant Disease Control Handbook* EM 3526, *Rose Varieties—Powdery Mildew & Rust Susceptibility*
Strawberry	Fruit Rot Root Rot—Red Stele Viruses Leaf Spot Leaf Scorch Red Stele Verticillium Wilt Viruses	*Northwest Plant Disease Control Handbook* EM 4262, *Root Rots of Raspberry & Strawberry in Home Gardens* USDA Farmers' Bulletin No. 1043, *Strawberry Varieties in the United States*
Tomato	Wilt—Fusarium Wilt—Verticillium Late Blight	*Northwest Plant Disease Control Handbook* EB 0958, *Late Blight of Potato and Tomato*
Watermelon	Wilt - Fusarium	*Northwest Plant Disease Control Handbook*
Wheat	Dwarf Bunt Fungus Leaf Stripe Stripe Rust	*Northwest Plant Disease Control Handbook* EM 4618, *Growing Winter Wheat in Western Washington*
Woody Ornamentals and Shrubs	Armillaria Root Rot Verticillium Wilt Phytophthora Root Rot (listed under Cypress Root Rot)	EM 4433, *Armillaria Shoestring Root Rot* EM 4204, *Verticillium Wilt of Maples* *Northwest Plant Disease Control Handbook*

*Numbered publications may be obtained from your county Extension office. The *Handbook* may be purchased from Oregon State University Bookstores, P.O. 489, Corvallis, OR 97330.

Small Fruit Disease Resistance

Many varieties of berry fruits can be grown in Washington. Each, however, has a different tolerance to various diseases. Tables 7 and 8 and the following section summarize how susceptible berry fruits are to diseases.

Black Raspberries

Black raspberries are subject to several diseases that cause rapid deterioration of individual plants and seriously limit the productivity and life of plantings. The diseases include verticillium wilt, anthracnose, and the viruses streak, mosaic, and curl. Breeding and testing go on continuously throughout the United States to develop or find varieties resistant to, or tolerant of, these diseases. Results have not been successful. The old varieties, Munger and Plum Farmer, are still the most popular in the Northwest. No other varieties have been found that are superior in yield, disease resistance, fruit quality, and plant characteristics.

Table 7. Tolerance of strawberry varieties to diseases.

Disease—Plant tolerance	Variety
Viruses (aphid transmitted)	
Tolerant	Totem, Benton
Intermediate	Shuksan, Tyee, Northwest Rainier
Susceptible	Hood, Puget Beauty, Olympus, Quinault
Red stele root rot	
Resistant	Siletz, Olympus, Hood, Totem, Rainier Shuksan, Tyee, Benton
Susceptible	Quinault, Puget Beauty
Fruit rot	
Very susceptible	Northwest
Moderately susceptible	Hood, Olympus, Rainier
Least susceptible	Shuksan, Totem, Tyee
Powdery mildew	
Tolerant	Hood, Totem, Benton, Siletz
Moderately tolerant	Shuksan
Very susceptible	Olympus, Northwest, Quinault
Verticillium wilt	
Very susceptible	Earlidawn*
Susceptible	Vesper*

*Varieties adapted to Eastern Washington.

Table 8. Tolerance of red raspberry varieties to root rot.

Tolerance level	Variety
Very susceptible	Canby, Skeena
Susceptible	Willamette, Meeker, Chilcotin, Heritage
Tolerant	Newburgh, Sumner

Nonsynthetic Insect Control

Most of us remember when reasonably good gardens could be grown with little or no use of insecticides. While a number of pests now encountered are recent imports from other countries, for the most part we face the same pest insect complex found in pre-DDT days. Fortunately, a few recent nonpesticide approaches to insect control have been developed. These new developments combined with many old-time practices make it possible to obtain reasonably insect-free garden produce without the use of synthetic insecticides. Bear in mind, however, that you must accept some level of damage greater than is presently acceptable. In avoiding the use of modern synthetics, the following recommendations must be considered:

1. Avoid or limit the growing of highly insect-susceptible crops.
2. Be willing to accept a certain amount of insect damage.
3. Prepare to expend additional labor to achieve control.
4. Plant and care for a larger garden than you normally would to obtain the necessary yield to offset insect losses.
5. Expect considerable damage from several soil insects and from codling moth on apples and pears (especially in Eastern Washington). We have no satisfactory control for these pests unless you use modern synthetics for codling moth and fumigants for soil pests.

Other publications are available through your county Extension agent on control of garden pests relying chiefly on short residual, low hazard, synthetic insecticides.

Insecticides and Their Properties

The following recommendations are not based entirely on nonpesticide approaches. The few suggested pesticides are not synthetics but are low hazard materials derived from plants, dormant and summer petroleum oils, and lime-sulfur and elemental sulfur.

Pyrethrins

Pyrethrins are derived from the dried flowers of a species of *Chrysanthemum* and have been used for controlling insects since ancient times. They have the property of "quick knockdown" and very short residual effects. Therefore, they must be used often. They are sold most frequently with an activator or synthergist (piperonyl butoxide, peperonyl cyclonene, or some other synergist). The use of pyrethrins wtihout these low hazard and safe activators would be much less effective, difficult to obtain, and almost prohibitive in cost. (Insecticides chemically similar to pyrethrins have been developed.) The pyrethrins kill insects only by contact. They are effective against a wide range of garden pests especially the soft-bodied forms, but will not control mites. Do not spray around fish ponds. Consult the label for specific usages. Sprayed edible portions of fruits and vegetables can safely be eaten soon after application, but read and follow the label carefully.

Rotenone

For centuruies natives of tropical Africa and South America used the rotenone derivative as a fish poison. Fortunately, although the chemical is highly toxic to most cold-blooded animals, it is safe for most warm-blooded types, including man. Natives make powder of the root of the *Derris* plant or related plants containing rotenone and place the material in a lake or stream to kill fish. The fish die quickly and can then be eaten. This chemical is still used to rid lakes from unwanted "trash" fish. In the mid-19th century its properties as an insecticide were discovered and it became widely used until the mid-1940s when DDT and other synthetics largely replaced it. It has longer residual action than the pyrethrins, but also requires repeated applications. *Rotenone is probably the best general-purpose, nonsynthetic (natural) garden insecticide available.* It can be used either as a dust or spray and kills a wide range of garden insects such as caterpillars, aphids, and certain beetles, but is ineffective against spider mites and soil insects. Read the label carefully for specific usages.

Nicotine

Long used as an insecticde, nicotine unfortunately controls only aphids, related soft-bodied

sucking insects, thrips, and a few species of caterpillars. It does not control most chewing insects. It is derived from the tobacco plant and is usually sold as a 40% liquid concentrate of nicotine sulfate (Black Leaf 40) which is then diluted with water and applied as a spray. Nicotine dusts are not normally sold for garden use because of the irritation to the operator. Nicotine is much less effective when applied during cool weather. It has short residual effects and can be used on vegetables very close to harvest. *Nicotine concentrate is extremely poisonous.*

There are several other plant-derived insecticides, such as sabadilla, Ryania, and hellebore, but unfortunately, with the execption of Ryania, which is used primarily for codling moth on apples and pears in southeast Canada, these are rarely available in the Pacific Northwest.

Dormant and Summer Oils

Petroleum oils have been used for insect control as early as 1787 and are still popular, although not used as extensively as they might be. *Apply them only on woody plants.* There are two principal types: the dormant oils which should only be applied on trees or shrubs which are in a dormant or delayed-dormant condition, and summer oils which can be used during the growing season but are also restricted to *woody plants.* To apply a strictly dormant oil during the growing season will severely burn foliage. For summer use, be certain to purchase oil especially prescribed for this purpose and apply only on those plants for which the material is recommended. There are some special oils which can be applied either summer or winter; however, the concentration used in summer is far less.

Oils control many insects and their eggs, such as overwintering leafrollers, and aphid and mite eggs, as well as nymphs and adults of aphids, scale insects, and mites. These oils must first be diluted with water. They contain emulsifying agents which facilitate their mixing when added to water. The oils cause little or no harm to most beneficial insects and resistance of pests to these sprays does not occur. They are nonhazardous to human health. occur. Do not apply oils during freezing weather. They are nonhazardous to human health.

Lime-Sulfur

Liquid lime-sulfur is an old timer still in commercial use. You use it much the same as for the dormant oils diluted with water. Do not apply to apricot trees at any time; you may injure the foliage. *Use only on woody plants and only during the dormant season,* or up to pre-bloom on some plants. The only exception is on caneberries where it can be used for dryberry mite and redberry mite in the spring when vegetative buds are 1/2 inch long. This material is particularly effective against pearleaf blister mites, rust mites and their close relatives, as well as for many insect eggs. These sprays also have fungicidal value. On fruit trees, lime-sulfur is often mixed with dormant oil to increase its efficiency. Use lime-sulfur with caution when you treat ornamentals near your house. The spray drift when dried is most difficult to remove from buildings and may cause stains on all types of painted surfaces.

Elemental Sulfur

A finely ground powder, elemental sulfur can be applied either as a dust or spray. In addition to controlling fungus diseases, it will also give some control of spider mites, especially during hot weather. Warning: do not use sulfur on most vegetables just prior to harvest if you plan to can the produce. *Small amounts of sulfur in the "preserve" can will produce sulfur dioxide which will cause the container to explode. It may also cause off-flavor.* Sulfur can be used safely on berries and other fruits without these hazards and on vegetables eaten fresh, dried, or processed for freezing. Sulfur is very safe—in fact, it is an element essential for good health.

Soaps

Soap diluted with water has been recommended for certain soft-bodied insects, such as aphids, since 1787. Most often these soaps were derived from either plants (coconuts, olive, palm, cotton seed) or from animal fat, such as whale oil, fish oil, or lard. Vegetable or plant-derived soaps are more effective than those derived from petroleum. Unfortunately, commercial soaps vary tremendously in composition and purity, therefore vary widely in effectiveness.

A gardener might try true soap suds from a known brand of inexpensive laundry soap against aphids on a limited scale first. Should this prove successful, the practice could be extended. Or some old-fashioned homemade soap may be prepared using inexpensive waste lard or tallow, lye, water, and borax (optional). Six pounds of fat and a can of lye will make 6 pounds of soap. For directions, see EM 3378, *Making Soap in the Home*, available from your county Extension office. There is now an insecticide soap sold commercially as such.

Insect Disease Organisms

There is a material available on the market called *Bacillus thuringiensis.* This is a type of bacteria which is particularly effective on caterpillar pests, such as loopers, leafrollers, and cutworms. Try to apply it when these pests are small caterpillars. As they become larger, it is harder to control them with this material.

Noninsecticide Insect Control

Many cultural practices reduce the susceptibility of garden plants to insect attack just as they do against disease attack.

1. Rotate your garden plot if you possibly can. This is often possible on the farm, since land suitable for gardens is more readily available. If an alternative crop cannot be grown on land suitable for gardens, you can at least change the sequence of plants grown in the garden plot. Should you develop a soil insect problem, such as wireworms or white grubs, avoid growing tuber or root crops, such as potatoes or carrots. Do not grow the same kinds of garden produce in the same place each year. Avoid planting your garden on recently plowed soil.

   Avoid or restrict the growing of insect-susceptible crops. Unfortunately, we have no nonsynthetic insecticides suitable for soil insects. Therefore, white grubs, wireworms, cabbage maggots, onion maggots, carrot rust fly, and other soil insects may continue to bother you. The cole crops (radishes, cauliflower, etc.) are highly susceptible to attack by both foliage insects, particularly the cabbage worm, and by cabbage maggots in the soil. Minimize or discontinue planting these crops and grow instead more insect-tolerant vegetables, such as beans, peas, chard, spinach.
2. Fertilize, cultivate, and water well to induce good, healthy growth. Insect injury is less damaging on a healthy plant.
3. Use interplantings (as opposed to solid plantings of a given species) to isolate the infestation and reduce damage.
4. Handpick and destroy pests when feasible by knocking pests from foliage into a bucket containing a mixture of water and kerosene, oil, or soap.
5. Use transplants. The longer a plant is growing in a garden, the greater is its exposure to potential insect attack. For this reason, plants of the cabbage family will avoid early and often devastating attacks of cabbage maggot if you purchase healthy, mature transplants or else grow them under glass for transplanting later. A healthy transplant will more likely overcome subsequent insect attack than a small plant developing from seed in the field.
6. Hot caps. Hot caps are recommended during the early growing season, not only for preserving heat, preventing wind and hail damage, but also for preventing early insect attack.
7. Sanitation. Since many garden insects overwinter in plant debris, spade under old plants, such as spinach, lettuce, etc., during the summer or add these plant residues to your compost. The cabbage aphid, for example, may overwinter as an egg on the cabbage plant; the adult asparagus beetle overwinters in the hollow stems of asparagus; and several species of leafhopper overwinter in or on plant debris. Immediately dispose of your cull onions since the onion maggot will continue to breed in them. Whenever a garden plant is no longer producing, spade it in or relegate it to the compost pile. Keep your garden free of weeds and volunteer plants: these can harbor pests—particularly certain aphids which may transmit disease organisms. Tall grasses and weeds that border your flower

or vegetable garden provide good cover for slugs, so keep the grass and weeds trimmed. Go easy on manure or compost: too much in your garden soil can encourage millipedes, white grubs, and other pests.

8. Cultivation. Cultivating a garden exposes those stages of pests which live near the surface of the soil to birds and injures or kills some insects. Fall cultivation is preferred since it also exposes pests to the rigors of winter.
9. Planting dates. Planting your crop prior to emergence of a particular pest or late planting to avoid resident first generations of the pest has shown that damage can be considerably reduced but not necessarily eliminated (for example, late planted cole crops can help reduce cabbage maggot damage). You should, however, check with your local authority on this approach since pest populations often peak at different times depending on geographical location.
10. Color attractants. It is a known fact that some insects are attracted to certain colors. This behavior can be used against them. An effective example is with whiteflies in greenhouses where yellow cards or boards are hung every few feet among the plants and are covered with Tack Trap® or Tanglefoot®. The whiteflies seem to be attracted to the yellow card and become stuck on the board. (See fig. 2.) In many instances 100% control of whiteflies is not necessary, such as in hobby greenhouses. Most plants can tolerate a low level of whiteflies. Heavy motor oil (SAE 90) is also an effective trapping material and is easier to wash off the boards. This may also work on whiteflies on crops outdoors, although tests have not yet been conducted to determine the effectiveness. These traps also catch a substantial number of fungus gnats.

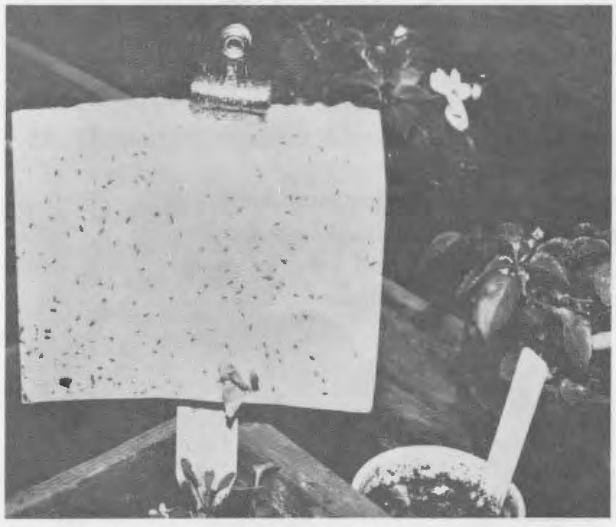
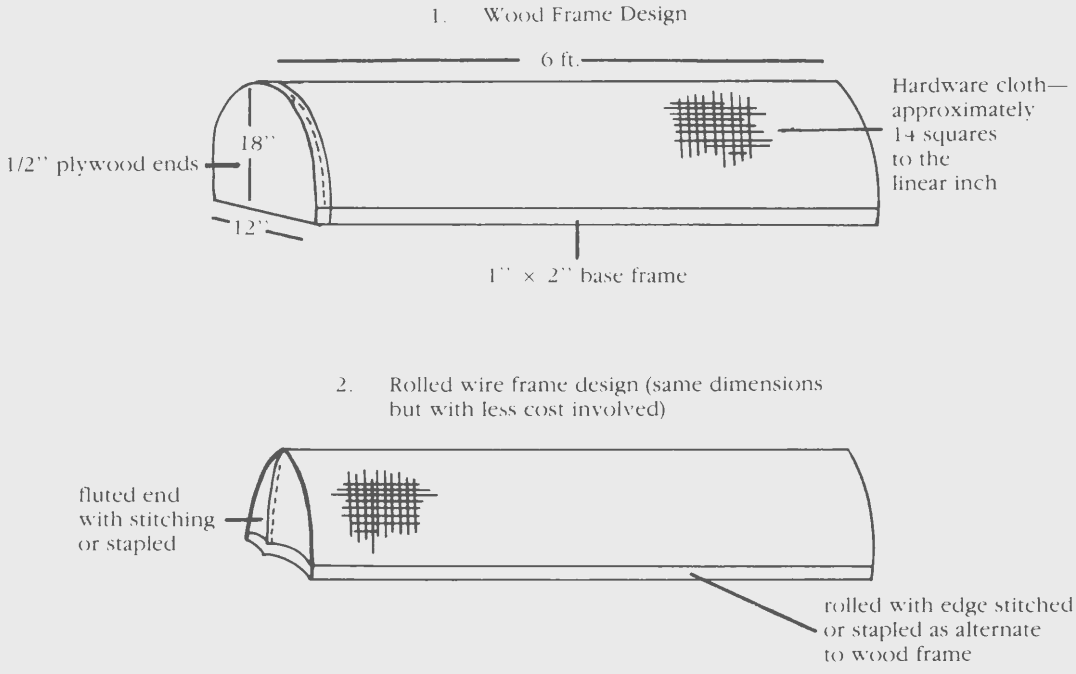


Fig. 2. Sticky yellow card for trapping whiteflies and fungus gnats.

11. Trap cropping. There are plants that pests prefer more than those in your vegetable garden. Having knowledge of these can help you steer these pests away from your more desirable plants. For example, nasturtiums are often heavily populated by certain aphids before they move onto other susceptible plants. Be sure to destroy them on the nasturtiums before they become abundant, or they will overflow onto other garden plants and you will not have accomplished a thing. This technique often works, but due to unknown variables in plant and insect interactions, it sometimes does not. Another example is in the control of fungus gnats in house plants and in the hobby greenhouse. Larval control of these gnats can be achieved by "trap cropping." Pots of sprouting grain often attract female gnats who lay their eggs near these plants. After a few days these pots should be submerged in boiling water to destroy the eggs and maggots or discarded outdoors. This practice should be repeated every 2 weeks until flies are no longer noticed.
12. Plant cages. Wire, nylon, or muslin screen cages are useful in small garden plots for excluding cabbage maggots from cole crops, radish, or turnips. The following designs have been used experimentally and have proven to be extremely effective. (See fig. 3.) These could also be used to keep out pea leaf weevils until seedling peas have reached the 4-6 expanded leaf stage at which point they are tolerant to weevil feeding.

Experimental units are 6 feet long, 1 foot wide, and 18 inches high. This design was most practical for host plants with tall leaf tops (turnips). The same unit could be used for broccoli, cabbage, and others. However, these crops will outgrow the height of the unit. This is of no importance since at that stage of growth the plants will no longer succumb to maggot damage, and the cages could simply be removed at that point. A cage of smaller dimensions (at less cost) is advised for radishes. Cages on radishes or turnips should remain until harvest. The following design is that used for our experimental gardens. The screen used is the typical mesh size found in any backdoor screen door (metal or nylon).



These designs are suggestions, and modification will suffice if it adequately keeps out flies. Whatever design is chosen, secure edges into soil, and if wind could be a problem, then secure with stakes and wire. For storage, either disassemble and hang on garage wall, or make each subsequent cage a little shorter and stack like sawhorses.

Fig. 3. Specifications for wire screen cage used for root maggot control.

13. Liquid attractants. Material like stale beer placed in cans sunk in the soil is very attractive to slugs which find the containers, crawl in, and drown. This material is also very attractive to many insects. The best way to control slugs is still to eliminate their nearby hiding places, such as tall grassy or weedy areas.

14. Plant "sleeves." Milk cartons with both ends cut out and placed snugly in the soil enclosing the plant will serve as a physical barrier to many pests. Additional protection will be provided if you apply a band of sticky or greasy material, like vaseline, to the exterior of the carton.

15. Other "insect barriers." Barriers are useful if some part of the known biology or behavior of the pest in question lends itself to manipulation by these methods. For example, most root weevils are night feeders. As day approaches, they drop off rhododendrons and other host plants to the litter below, where they hide. If the main trunk is the only access to crawling back up the plant to feed on foliage, the trunk then is an ideal place to consider a barrier. A strip of plastic or plant wrapping paper wrapped snuggly around the base of the trunk with a sticky material (such as Tanglefoot™) applied to the strip has provided an efficient barrier to root weevils. The strip should be checked from time to time, since debris and insect accumulation will render it ineffective over time. (Remove during winter.)

16. Resistant varieties. Many plant species have varieties that are either moderately or highly resistant to plant pests. Unfortunately, many are not available to or known by name to the home gardener. Some lists are available, however. See EB 0970, *Root Weevil Control on Rhododendrons* for such a list of species and varieties of rhododendrons and azaleas which demonstrate resistance to root weevils.

    Some other pest-plant relationships are known about strawberries and raspberries.

    Strawberry. There is little resistance in strawberry varieties to major pests such as root weevils and aphids. However, resistance to the two-spotted spider mite has been found in the Linn variety. All other varieties are susceptible. The Totem variety is extremely susceptible.

    Raspberry. There is little resistance in red raspberry to the major pests. However, resistance to the raspberry aphid, an insect which spreads virus diseases, can be found in Canby, Haida, Skeena, and Nootka varieties.

17. Water. The mechanical damage and displacement the common garden hose will provide is particularly useful in controlling aphids on certain garden plants. The force of the well-directed spray will kill or dislodge many of the aphids. Those that withstand the force rarely make it back to the host plant. You will, however, miss some which in turn will repopulate, so be prepared to include this method regularly in your normal gardening operations. Also, plant foliage which is highly susceptible to mildew should not be sprayed with water at night. Spray during the daytime so that pooled water on foliage has a chance to dry rapidly.

18. Other methods. There is much publicity on the use of light traps, reflective materials, such as aluminum foil, irradiation, electric shock, repellants, and the use of sex lures. Most of these methods cannot be recommended for the gardener at present, although eventually they may be of considerable value.

Biological Control of Insect Pests

Biological control is the use of any form of life to control a pest. A controlling agent may be a disease organism, a predacious or parasitic insect, predacious spiders and mites, insect-feeding birds, rodents, toads, or any other vertebrates. A number of companies now supply insect and mite predators and parasites to gardeners and farmers. For a current and complete listing, refer to magazines on organic gardening. Your Extension office may have partial lists. Many of these beneficial organisms occur naturally, but often effective numbers develop too late to control the pest before severe damage occurs. Keep in mind also that when introducing an insect to prey upon or parasitize a pest animal, its numbers can only be increased in nature if it has sufficient prey to feed upon. If you are experiencing little insect damage or the pest species are in low numbers or absent, the beneficial organisms must move elsewhere, where food is available to survive. To allow beneficials that feed on pests to increase in number sufficiently to control pest insects, you must accept a certain amount of insect damage. You can't have insect-free garden produce and encourage beneficial insects at the same time. Releasing predators or parasites can be very beneficial in establishing them in new areas.

The nonsynthetic insecticides mentioned in this bulletin are definitely less hazardous to beneficial insects than many of the synthetic pesticides, *but*, they should be used only when absolutely necessary in order to preserve as many beneficial forms as possible.

Lady Beetles

The use of lady beetles as an approach to aphid control has long been utilized by the organic gardener. The process includes purchasing the beetle in bulk quantities and releasing them at the site. The idea is a good one; however, there are aspects of the beetle's biology that thwart the total effectiveness of such a practice. These beetles overwinter as adults in large masses in the forests or hillsides. They are collected at this time and kept in cold storage until they are sold. The beetles are often released in large numbers on a single site (backyard) and expected to remain. The aphid population is frequently not large enough at the time of release to support such a population of lady beetles, so they do what any hungry animal would do under such circumstances—leave the area in search of sufficient food. Furthermore, it is the belief of many entomologists that most species of lady beetle must undergo a dispersal flight after overwintering before they settle down, mate, and lay eggs. This is a phase which is missing in the beetle at the time of purchase, so when they are released they take flight and leave the area. Thus, the beneficial effects are only realized by unknowing, nonpaying neighbors. Some blueberry growers have used this technique for many years, and since several are doing so on an area-wide basis, they are apparently accidentally achieving success by trading beetles through a random multi-directional dispersal flight.

Birds

Birds are far more important in preventing insect outbreaks than in controlling them. All bird species feed upon insects to some degree. The flycatchers, swallows, warblers, vireos, creepers, nuthatches, and woodpecker are almost entirely insectivorous, while blackbirds, robins, crows, gulls, magpies, and even the birds of prey, the hawks and owls, commonly feed on insects.

To develop bird numbers near gardens one must encourage those species which feed largely upon insects. If you encourage all species of birds, including those which damage gardens, such as starlings, robins, blackbirds, etc., you may be asking for trouble. Insect-feeding birds can best be encouraged by providing cover, supplementary feed, and prevention of predation from cats and other predators. (See tables 9 and 10.)

Many insectivorous birds can be attracted to your home by planting those ornamentals which provide suitable bird cover and food. Some especially valuable plants are:

Dogwood
Mountain Ash
Russian Olive
Firethorn
Crabapple
Elderberry

Sumac
(Aromatic and Staghorn)
Holly
Hawthorne
Highbush Cranberry
Cherry
Wild Plum
Cotoneaster
Red Cedar
Bittersweet

For further information about attracting birds, see EB 1043, *Garden Insect Control without Synthetics*, available through your county Extension office.

Table 9. Nesting box dimensions for various bird species.

Species	Floor of cavity	Depth of cavity	Entrance above floor	Diameter of entrance	Height above ground*
	Inches	*Inches*	*Inches*	*Inches*	*Feet*
Bluebird	5 X 5	8	6	1 1/2	5-10
Robin	6 X 8	8	†	†	6-15
Chickadee	4 X 4	8-10	6-8	1 1/8	6-15
Titmouse	4 X 4	8-10	6-8	1 1/4	6-15
Nuthatch	4 X 4	8-10	6-8	1 1/4	12-20
House wren	4 X 4	6-8	1-6	1 1/4	6-10
Bewick's wren	4 X 4	6-8	1-6	1 1/4	6-10
Carolina wren	4 X 4	6-8	1-6	1 1/2	6-10
Violet-green swallow	5 X 5	6	1-5	1 1/2	10-15
Tree swallow	5 X 5	6	1-5	1 1/2	10-15
Barn swallow	6 X 6	6	†	†	8-12
Purple martin	6 X 6	6	1	2 1/2	15-20
Song sparrow	6 X 6	6	‡	‡	1-2
House finch	6 X 6	6	4	2	8-12
Starling	6 X 6	16-18	14-16	2	10-25
Phoebe	6 X 6	6	†	†	8-12
Crested flycatcher	6 X 6	8-10	6-8	2	8-20
Flicker	7 X 7	16-18	14-16	2 1/2	6-20
Golden-fronted woodpecker	6 X 6	12-15	9-12	2	12-20
Red-headed woodpecker	6 X 6	12-15	9-12	2	12-20
Downy woodpecker	4 X 4	8-10	6-8	1 1/4	6-10
Hairy woodpecker	6 X 6	12-15	9-12	1 1/2	12-20
Screech owl	8 X 8	12-15	9-12	3	10-30
Saw-whet owl	6 X 6	10-12	8-10	2 1/2	12-20
Barn owl	10 X 18	15-18	4	6	12-18
Sparrow hawk	8 X 8	12-15	9-12	3	10-30
Wood duck	10 X 18	10-24	12-16	4	10-20§

*During an experimental birdhouse study, boxes at moderate heights mostly within reach of a man on the ground were readily acceptable.

†One or more sides open.

‡All sides open.

§Based on experience gained on national wildlife refuges, where approximately 2,500 boxes have been erected for hole-nesting waterfowl.

Table 10. Bird groups and feeds they like.

Bird Group	Readily Accepted Foods
Woodpeckers	Suet, cracked nuts, corn
Jays	Suet, cracked nuts, corn, peanuts, sunflower seeds
Titmice, chickadees, nuthatches	Suet, cracked nuts, shelled and broken peanuts, sunflower seeds, bread crumbs
Mockingbirds, catbirds, thrashers, hermit thrushes, robins	Cut apples and oranges, currants, raisins, bread crumbs
Grosbeaks, cardinals, towhees	Sunflower seeds, corn, shelled and broken peanuts, scratch feed
Juncos, finches, native sparrows	Scratch feed, millet, wheat, screenings, small seed mixtures, bread crumbs

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