9

Controlling Insects and Diseases

Successful vegetable production requires the effective and economic control of insect and disease pests. The commercial vegetable gardener must produce a quality product that is attractive and safe to the consumer at a minimum cost. Losses in produce yield and quality due to insect and disease damage are unacceptable.

Effective, economic pest control or pest management requires the use of cultural, mechanical, biological, and chemical methods. For best results, a combination of these is usually necessary. Insecticides and fungicides are highly effective in the control of most insect and disease pests, but their use is closely regulated by state and federal agencies and is subject to change even in mid-season. It is imperative that the commercial grower secure the latest recommendations for any pesticide use. Since growers are interested in maximum control at minimum costs, it may be necessary for them to consider a wide range of materials. The home gardener, who usually grows a variety of vegetables, may encounter many pests. A limited number of generally effective pesticides that should be safe to apply, handle, and store may be used.

IMPORTANCE OF PEST CONTROL

Insect and disease infestations in vegetable crops bring about heavy losses through (1) reduced yields, (2) lowered quality of produce, (3) increased costs of production and harvesting, and (4) required expenditures for materials and equipment to apply control measures. These losses individually and collectively are important because they reduce the vegetable grower's income and may result in the total loss of a crop.

The insect- and disease-control picture in vegetable production has changed considerably with the appearance of more effective pesticides in the late 1980s. Control measures have become more selective, and yields of crops such as potatoes have increased greatly. The Environmental Protection Agency (EPA), which regulates the registration and use of pesticides on vegetables, sets the tolerances for miniscule amounts of residues that are allowed on a crop at the time of harvest. It is the federal Food and Drug Administration (FDA), however, that enforces these tolerances on fresh vegetables by random sampling and residue analysis at any point during shipping and marketing.

The continual tightening of pesticide regulations by the EPA has resulted in the present tendency for growers to use a minimum of pesticides, and only those that disappear rapidly and are readily biodegradable. Consequently, renewed interest is being devoted to research on biological and cultural methods of control and insect- and disease-resistant cultivars.

GENERAL CONTROL MEASURES

The recommended insecticides and fungicides are by no means the complete and final answer to insect and disease problems arising in vegetable production. It is true that there are chemical controls for practically every disease and insect problem, but pesticides are used only as a last resort and not as the only method of control. Frequently, when the problem arises, there may be no other options, a situation that quickly demonstrates dependance on these chemical tools and lack of knowledge of the basic biology that would permit the use of other control methods.

Several "common sense" practices, when incorporated into the insecticide-fungicide program, will improve yield, increase produce quality, and in the long run, decrease production costs and increase profits. These fundamentals can be found in almost any text devoted to the art and science of vegetable production as well as in publications of the United Sstates Department of Agriculture (USDA) and of state extension services and experiment stations. The following are offered for the convenience of the reader:

1. ***Plant the best-quality seed.*** This means that the seed should be (a) disease-free and (b) certified when possible.

2. ***Select crops that are best suited to your soil and climate.*** Because a crop is not grown in your area does not mean it cannot be grown there, but it usually is a good indication.

3. *Control weeds.* Grass and broadleaf weeds compete strongly with crops for soil moisture and plant nutrients, and they frequently harbor or attract insects that may later attack the crop and may also serve as disease reservoirs.

4. *Control insect pests as needed*, especially leafhoppers and aphids. Several viral diseases are transmitted by insects with piercing, sucking mouthparts.

5. *Select plots of land that are fertile and well drained.* Substandard land will produce substandard yields, while poorly drained areas will invariably result in sparse stands, damping-off, and seed-decay problems.

6. *Use only the best-quality fertilizers.* Soil tests will indicate what fertilizer combination is needed and whether liming is necessary. Fertilizer bargains are seldom found.

7. *Buy plants the same as seed, disease-free and certified* (when possible).

8. *Use disease-resistant cultivars if available.* At present these include cultivars that are resistant to only a few diseases of specified crops, but the number is increasing. The degree of resistance varies considerably through the range of available cultivars.

9. *When harvest is completed, destroy the remains of annual crops as soon as practical.* Stems, leaves, and roots can serve as disease reservoirs and insect harbors for the following year.

10. *Rotate crops.* Planting the same crop in a field year after year may eventually result in severe soil-borne diseases and insect or nematode infestations. All of these can be held in check to some degree by crop rotation.

11. *Follow recommended planting dates for your area.* Some crops can be planted so they will mature before diseases strike and before or after certain insects begin their attack. Planting dates are usually issued by the individual cooperative extension services or state experiment stations.

CONTROLLING INSECTS

The number of insect pests of vegetable crops is quite long and diversified (Table 9.1). Some insects cause significant damage in all areas where vegeta-

Table 9.1. Insects That Commonly Attack Vegetable Crops

Vegetable	Insect Pest
Asparagus	Asparagus beetle, cutworm, thrips, wireworm
Beans	Aphid, bean leaf beetle, corn earworm, cutworm, leafhopper, Mexican bean beetle, root maggot, spider mite, cucumber beetle, western bean cutworm, wireworm, lygus bug, flea beetle
Beets	Beet webworm, blister beetle, cutworm, flea beetle, wireworm, white-fringed beetle grub
Cabbage, broccoli, cauliflower, kale	Aphid, cabbage looper and caterpillars, cutworm, flea beetle, harlequin bug, mole cricket, root maggot, vegetable weevil, white-fringed beetle grub, wireworm
Carrots	Carrot rust fly, leafhopper, vegetable weevil, wireworm
Celery	Aphid, celery leaf tier, cutworm, lygus bug, spider mite
Cucumbers and melons	Aphid, cucumber beetle, leafhopper, leaf miner, pickleworm, spider mite, thrips, wireworm
Eggplants	Colorado potato beetle, cutworm, eggplant lace bug, flea beetle, hornworm, spider mite, whitefly, wireworm
Lettuce	Aphid, armyworm, cutworm, caterpillars, leafhopper, mole cricket, wireworm
Onions	Onion maggot, thrips, wireworm, leaf miner
Peas (garden)	Aphid, pea weevil, alfalfa and celery loopers
Peppers	Aphid, cutworm, flea beetle, hornworm, leaf miner, pepper maggot, pepper weevil, spider mite, wireworm
Potatoes	Aphid, armyworm, blister beetle, Colorado potato beetle, cutworm, European corn borer, flea beetle, grasshopper, leafhopper, mole cricket, plant bug, potato psyllid, potato tuberworm, vegetable weevil, white-fringed beetle grub, white grub, wireworm
Pumpkins and squashes	Aphid, cucumber beetle, cutworm, squash bug, squash vine borer, pickleworm
Spinach	Alfalfa looper, aphid, beet webworm, leaf miner
Sweet corn	Corn earworm, European corn borer, Japanese beetle, wireworm
Sweet potatoes	Sweet potato weevil, wireworm, white-fringed beetle grub
Tomatoes	Aphid, armyworm, blister beetle, Colorado potato beetle, cutworm, drosophila, flea beetle, hornworm, leaf miner, spider mite, tomato fruitworm, tomato pinworm, tomato psyllid, tomato russet mite
Turnips	Aphid, caterpillars, flea beetle, root maggot, vegetable weevil, wireworm, white-fringed beetle grub

bles are grown, while others may be more localized to certain geographical areas. Certain insects are pests for a wide variety of crops, while others are more specific in their host range. Many insects feed directly on plant tissue, while others cause damage by sucking out plant fluids.

Effective insect management requires proper identification and a knowledge of the insect's biology and habits. In general, insect pests of vegetables can be divided into six categories: (1) beetles that chew holes in plant foliage;

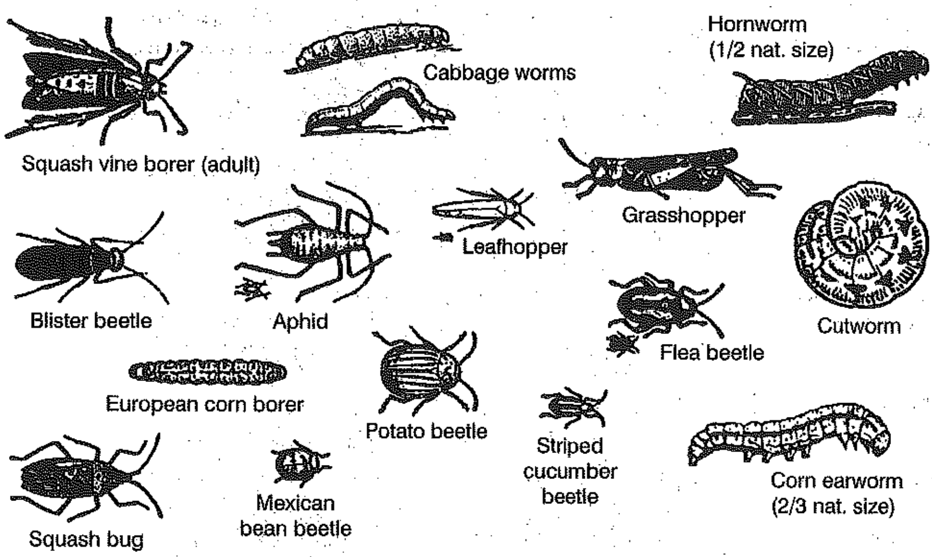

Figure 9.1. Common insect pests of vegetable crops. (Insects are approximately natural size, except where otherwise indicated. Where two drawings are shown, the smaller one is the natural size.)

(2) caterpillars and worms that feed on foliage and sometimes on fruit; (3) cutworms, earworms, and borers that tunnel into corn ear tips and various vegetable fruits; (4) soil maggots, grubs, and wireworms that feed inside seeds and on plant roots; (5) aphids, whiteflies, scale, and mites (covered here although not true insects) that feed in large numbers by sucking juices from new foliage; and (6) adult and immature plant bugs that suck plant juices from foliage and fruit. Illustrations of some of the more major vegetable insect pests are given in Figure 9.1.

Scouting for Insect Pests

Vegetable producers, or a specialist hired for the purpose, should check or scout their crops every two or three days, carefully examining them for signs of insect infestation, such as eggs, insect frass, and damaged leaves or fruit. In this way, most insect pests can be discovered and control measures applied before the problem seriously enlarges. In many of the major sweet corn growing areas, commercial growers set out light traps and pheromone traps to monitor the seasonal population levels of corn borers and earworms, respectively.

The value of scouting fields to determine the need and proper time for control applications cannot be overemphasized. A knowledge of the extent of infestation and the stage of insect development will in the long run save the producer time, money, and worry.

Insecticides

Although insect management programs in vegetable crops include cultural, mechanical, and biological methods, insecticides are still the most efficient means of managing most insect pests.

Insecticides used on vegetables can be divided into two broad categories: (1) inorganic compounds and (2) organic compounds. The inorganic insecticides, which include cryolite and various types of sulfur, are generally not used very much. Rather, the organic insecticides make up most of the chemical insecticides used on vegetables today. They consist of botanical compounds derived from plants and plant parts (e.g., pyrethrum and rotenone) and various synthetic organic chemicals, including chlorinated hydrocarbons, organic phosphates, carbamates, and pyrethroids. These last two groups are widely used commercially since they kill a broad spectrum of insects but have relatively low mammalian toxicity.

A list of some common insecticides for use on vegetable crops is given in Table 9.2. Some of the insecticides are toxic and their use is restricted to certified applicators only. Several of the insecticides have limitations in days between application and harvest. This and other information, including directions, cautions, and restrictions, are indicated on the label.

Home gardeners can generally limit their use of the available insecticides to *Bacillus thuringiensis*, carbaryl (Sevin®), and malathion for foliage application, and diazinon for soil insects. Commercial growers are usually more specific in their insecticide choice. The choice is based on several factors, including cost of the chemical, application costs, the relative effectiveness, the gain in profits that can be expected from application, the effect of the chemical on other pests, and the effect of the chemical on predators, parasites, and pollinators.

No specific crop insecticide recommendations are given here due to the constant introduction of new chemicals and materials and to changes in insecticide registration labels. For the most up-to-date information on insecticide registration and use-restrictions, growers and gardeners should contact their state extension specialists.

Table 9.2. Some Common Insecticides and Acaricides Registered for Use on Vegetables[a]

Common Name	Trade Name	Formulation
Abamectin	Agri-Mek	0.15EC[b]
Acephate	Orthene**	75S
Azadirachtin	Align, Neemix	
Azinphosmethyl	Guthion**	2L, 3F, 50WP
Bacillus thuringiensis	Bacillus thuringiensis	(many)
Carbaryl	Sevin**	50WP, 80S, 5B, XLR
Carbofuran	Furadan**	4F
Chlorethoxyfos	Fotress	5G, 2.5G
Chlorpyrifos	Lorsban**	4E, 15G, 50W
Cyfluthrin	Baythroid, Aztec**	2EC, 2.1G
Cyhalothrin	Warrior**	1EC
Cypermethrin	Ammo**	2.5EC
Diazinon	Diazinon**	50WP, AG500, 4EC, 14G
Dimethoate	Dimethoate**	E267
Disulfoton	Di-Syston*	8EC, 15G
Endosulfan	Thiodan, Endosulfan*	50WP, 3EC
Esfenvalerate	Asana**	0.66EC
Ethoprop	Mocap	10G, 20G, 6EC
Fonofos	Dyfonate	4EC,10G,15G, 20G
Imidacloprid	Admire, Provado	2F,1.6F
Malathion	Malathion**	(many)
Methamidophos	Monitor**	AC
Methomyl	Lannate**	90WSP, 2.4WSL
Methoxyclor	Methoxyclor	50WP, 2EC
Methyl parathion	Penncap-M**	2F (encapsulated)
Naled	Dibrom**	8EC
Oxamyl	Vydate*	2WSL
Oxydemeton-methyl	Metsystox-R*	2SC
Permethrin	Ambush, Pounce**	2EC, 25WP, 3.2EC, 1.5G
Phorate	Thimet*	15G, 20G
Phosmet	Imidan**	70WP
Sodium ammonium fluoride	Cryolite, Kryocide	96%
Terbufos	Counter	15G, 20G
Thiodicarb	Larvin	3.2

[a]Source: Foster, R., D. Egel, E. Maynard, R. Weinzierl, M. Babadoost, H. Taber, L. W. Jett, and B. Hutchinson. (eds.). 2000. *Midwest Vegetable Production Guide for Commercial Growers.* Purdue Univ. Coop. Ext. Ser. ID-56.

[b]AC (aqueous concentrate), B (bait), E or EC (emulsifiable concentrate), F (flowable), G (granules), S or SP (sprayable powder), W or WP (wettable powder), WSL (water soluble liquid), WSP (water soluble powder).

*(moderately toxic to bees), **(highly toxic to bees).

Insecticide Formulations

Insecticides for use on vegetables may be found in several different forms, including emulsifiable and flowable concentrates, wettable powders, granules, and other various formulations. No single insecticide is found in all forms. Emulsifiable or flowable concentrates and wettable powders are manufactured to be diluted with water to the desired concentration and sprayed with hand or power equipment. Dusts are almost never used commercially, but rather only by the home gardener, and are used in standard hand and power dusting equipment in the form in which they are purchased. All three forms have their advantages, depending on the insect to be controlled, the crop, the terrain, the weather and ground conditions, and the equipment available.

Granulars are another form of insecticide, used mostly for soil insects. Small clay pellets are evenly impregnated with insecticide and can be distributed by aircraft, fertilizer and seeding equipment, or with equipment made especially for granular application.

Biological Control

Microbial insecticides obtain their name from microbes, or microorganisms, which are used to control certain insects. *Bacillus thuringiensis* is a disease-causing bacterium that produces substances toxic to insects. More than 400 species of leaf-feeding caterpillars are known to be controlled by this important insect pathogen. It is sold under several trade names, as a liquid concentrate or a wettable powder, to be sprayed on infested plants. This form of insect control has two advantages: (1) insect predators and parasites are not killed, and (2) no harmful chemical residues remain on the produce at the time of harvest. *Bacillus thuringiensis* is available for home gardeners as well as commerical growers and is very effective for most leaf- and fruit-eating caterpillars.

BEES AND POLLINATION

For vegetables such as cucumbers, melons, pumpkins, and squashes that are grown for their fruits and have a monoecious (i.e., separate male and female flowers) flowering habit, pollination by bees is essential for good fruit-set and development. Pollen in these crops tends to be heavy and sticky, making pollination by wind extremely difficult. Subsequently, the most reliable vectors for pollination in these vegetables are insects, primarily bees. In the process of collecting both nectar and pollen as food sources, bees provide the primary means by which pollen is transferred between male and female flowers. This aspect is so important to production that many commercial growers routinely use honey bees, either locally supplied or shipped in, to supplement existing native bee populations to ensure ample pollination in these crops.

The choice of pesticide, as well as application practices, can have a significant effect on bee activity. Insecticides such as Sevin, Diazinon, Malathion, and Orthene are highly toxic to bees. These products can cause severe losses when used where bees are present or are active within several days after application. Insecticides such as Thiodan and Di-Syston are moderately toxic and will cause losses if applied directly to bees but can be used provided precautions are taken to minimize drift and direct contact with bees. Bee visits to flowers usually begin one to two hours after sunrise, when the flower first opens, and continue until late afternoon, with peak activity usually around mid-morning. In general, insecticides should be sprayed early in the morning or in the early evening, when bee activity is low. The toxicity level of various insecticides to bees is indicated in Table 9.2.

CONTROLLING DISEASES

As with insect control, disease control is an important phase of vegetable production. Disease-control measures must begin before the disease is observed in the field. In contrast, measures for controlling insects are usually withheld until insects or their damage is observed.

Disease control begins with soil sterilization and seed treatment and continues with applications of fungicides (materials used to kill or control plant diseases) to the growing plant. Even though disease control appears more complicated with the ever-increasing number of new fungicides, the task has actually been simplified. Most vegetable diseases can now be prevented before they strike. Where fungicides have not been applied in time to prevent disease, they may, in some circumstances, be used to decrease the severity of damage after the disease has become established.

Soil Sterilization and Seed Treatment

If possible, the soil should be sterilized to kill fungi, bacterial spores, insect larvae and pupae, and weed seeds. The grower can do this by using a formaldehyde drench, treating with chloropicrin (a tear gas), dipping bagged soil into boiling water for several minutes, or heating the soil with live steam. Where live steam is available, as in steam-heated greenhouses, steam treatment is the most practical method.

For best results, soil sterilization should be combined with seed treatment. While sterilization of the soil will control many soil-borne diseases that begin with seed germination, it will not control those that are seed-borne. These are controlled by coating the seeds with a good seed protectant, either as a dust or as a slurry. Seed treatment is especially important where soil sterilization is not feasible, such as in field seedlings.

Seed can be purchased already treated at the packaging house, and typically all commercial seed is pre-treated. But if not, it can be treated by the grower, usually without any special equipment. Some of the materials commonly used for seed treatment are captan and thiram. Some seed can be hot-water-treated, but this technique, though very effective, is delicate and requires precise time and temperature control.

Fungicides

After seedlings have been transplanted in the field or field seedlings have sprouted and begun to develop, the next stage of disease prevention must be considered. Occasionally, some seedlings such as cabbage and pepper can be dipped in a fungicide solution just before transplanting to provide further protection while the plants are adjusting to climatic and soil changes. The new, automatic seedling transplanting machines have the capacity to add a fungicide to the water that is applied during transplanting.

Best results are obtained when the fungicides are applied before there is any evidence of plant damage to protect the plants during the stage when they are susceptible to pathogens. With some of the newer fungicides, applications can be delayed until disease symptoms appear without seriously affecting the crop. However, with crops whose sale value depends heavily on cosmetic quality or appearance, such as celery and lettuce, this cannot become the practice.

Some of the fungicides approved for use on vegetables are given in Table 9.3. As with insecticides, fungicides are included under EPA regulations. These regulations limit the amount of fungicides that can remain as residue on or in crops at the time of harvest.

Table 9.3. Some Common Fungicides Registered for Use on Vegetables[a]

Comon Name	Trade Name	Formulation[b]
Azoxystrobin	Quadris	2.08EC
Benomyl	Benlate	50WP
Chlorothalonil	Bravo	720F, 82.5DG, 75WP
DCNA	Botran	75WP
Dinocap	Karathane	25WP, 4LC
Iprodione	Rovral	50WP
Mancozeb	Dithane M-45 Manzate	80WP, 80DG 80DG
Maneb	Maneb	80WP, 75DF
Mefenoxam	Ridomil	44DG,47EC, 76W,
Propiconazole	Tilt	3.6F
Thiophanate	Topsin	70WSB
Triadimefon	Bayleton	50WP
Basic copper sulfate	Basicop	53WP
Copper resinate	Citcop	5EC
Copper hydoxide	Kocide	50WP, 4.5F

[a]Source: Foster, R., D. Egel, E. Maynard, R. Weinzierl, M. Babadoost, H. Taber, L. W. Jett, and B. Hutchinson. (eds.). 2000. *Midwest Vegetable Production Guide for Commercial Growers*. Purdue Univ. Coop. Ext. Ser. ID-56.

[b]DF (dry flowable), DG (dispersible granules), EC (emulsifiable concentrate), F (flowable suspension), LC (liquid concentrate), W or WP (wettable powder), WSB (water soluble bag).

Fungicide Formulations

Some fungicides can be applied as either sprays or dusts, but sprays are generally preferable because the films stick more readily, remain longer, and can be applied even during mild breezes. Dusts can be applied only when there is little or no wind. With the older fungicides, only that portion of the plant that has a coating of dust or spray film is protected from disease. This is not the case with the newer systemic fungicides, which are taken into the plant and moved rather uniformly throughout the stems and leaves, thus not requiring the complete coverage of the older fungicides.

Normally, applications must be repeated when the coating or film wears off or is washed off. In common practice, applications are made at 7- to 10-day intervals. In wet weather more frequent applications are necessary for two reasons: (1) the fungicide may be washed off by the rain and (2) some disease pathogens survive better during wet or damp weather than during dry conditions.

Antibiotics

Antibiotics are occasionally used in disease control. Strangely enough, they are produced by living fungi. At present, streptomycin is used primarily on bacterial diseases such as bacterial spot on peppers and tomatoes, but in rare situations it is effective against some fungal diseases. It has been recommended for use on seedling beds and on potato seed pieces.

NEMATODES

Nematodes are neither insects nor fungi, but they do injure all vegetable crops to some extent, depending on the crop, the soil type, and the consecutive number of years the same crop has been planted on the same field.

Nematodes are small eelworms, usually less than $^1/_{16}$ inch long, that live in and on the roots and surrounding soil of all vegetable crops. One nematode, the root knot nematode, is fairly widespread. It receives its name from the small, distinct galls it causes on the roots of cabbage and other crucifers. These galls vary from the size of a pinhead to 1 inch in diameter.

Nematodes usually feed and produce their young on the roots of a great number of plants. They live in the soil and in decaying vegetable material from one year to the next. The importance of their damage is not yet fully recognized by either growers or research scientists.

These tiny pests can be controlled in two major ways: (1) by including nematode-resistant cultivars or crops in the rotation system and (2) by fumigating the soil. Fumigation is quite expensive and requires highly skilled applicators. Additionally, most of the soil fumigants have been removed from the market either by their manufacturers or by the EPA. When used as a nematicide, the fumigant is applied several inches deep and is allowed to spread evenly through the soil to kill the nematodes. This usually requires several days before the soil can be worked for planting.

TIMING—THE CRITICAL PERIOD

With few exceptions, vegetable crops represent the highest acre investment of all forms of agricultural endeavor. In the value of the harvested crop, they again take the dollar lead. Each year's harvest usually represents an enormous number of worker-hours and a tremendous investment in irrigation equipment, fertilizer, and special planting, harvesting, and processing machinery.

Considering the expense and effort involved in preparing a crop for market, it would seem unreasonable to permit an insect or disease pest infestation to lower the market grade or even, as occasionally happens, destroy the crop.

Yet, this very tragedy does occur, not because of the producer's failure to apply pesticides but because of several other factors. These include (1) poor timing of pesticide application, (2) improper selection of pesticide material, (3) unfavorable weather conditions, (4) low rate of application, (5) failure of equipment, and (6) negligence of operator.

Timing of application is the most important and probably the least attended of these factors. Insect and disease pests usually have a time in their development that can be referred to as the "critical period"; that is, a time in which they are most vulnerable to control. The critical period could also be applied to some stage in the growth of the plant, or even to the minimum number of days a material can be applied before harvest, according to EPA (and sometimes state) regulations. When planning insect and disease control, growers should consider carefully all three critical periods.

PESTICIDE LABELS

The label on a pesticide container gives instructions for its use and should be read and followed carefully. Maximum rates suggested should not be exceeded; the insecticide should be applied only to crops that are listed on the label; and the interval between application and harvest should be carefully observed. A record should be made of the product used, its trade name, the percentage active ingredient of the pesticide formulation, the dilution rate, the rate of application per acre, and the date(s) of application.

The "Read the label" cannot be overemphasized with respect to all pesticide applications. The commercial grower must follow a disease-control program that will assure the production of vegetables with no excessive fungicide residues.

Limits on the residues of insecticides and fungicides that can remain in or on raw agricultural commodities are carefully regulated by the EPA. These allowable amounts of pesticide residues on produce are known as *tolerances*. Vegetables marketed with residues exceeding EPA tolerances may be injurious to consumers, may be seized by the Food and Drug Administration, and may cause the grower to be heavily penalized. Many of the pesticides listed in Tables 9.2 and 9.3 will have limitations on the time in days between the last application and harvest.

Growers can have total confidence in the existing pesticide regulations as long as they use pesticides according to the current label and only on the crops specified, in the amounts recommended, and at the times indicated. These regulations are subject to change without notice and do not constitute recommendations for insect and disease control. For precise and timely information, growers should consult their state extension specialists for the latest suggested measures.

Although these regulations were designed primarily to protect the consumer, they also protect the vegetable producer and the pesticide manufacturer. The producer should follow the label directions for rate and time of application, which must appear on every pesticide container. By adhering to the manufacturer's directions, the grower is assured of placing produce on the market that will meet with tolerances established by the EPA. On the other hand, if the grower neglects to follow the label directions, the resulting harvested produce may be seized for having pesticide residues above tolerance. Under these conditions, the grower must assume complete responsibility for residues in excess of tolerance. Obviously, it is extremely important to read and follow label directions.

COMBINING INSECTICIDES AND FUNGICIDES

Disease and insect problems frequently occur at the same time. Under such circumstances, both the insecticide and the fungicide may be applied together, in one operation, provided they are chemically compatible. Some materials, however, are not compatible with others. Applying incompatible materials together can reduce control of the insect, the disease, or both. This happens through chemical action or breakdown of the compounds in the spray tank.

To be certain that two materials can be mixed in the same spray application, growers should consult compatibility charts (graphs or tables that show which materials can and cannot be mixed together). They are usually available on request from pesticide dealers or cooperative extension specialists.

SAFE HANDLING OF INSECTICIDES AND FUNGICIDES

All insecticides and fungicides are toxic to both humans and animals to some extent. The persons most likely to encounter these hazards are the spray tank mixers and the applicators.

Mixers and applicators may have pesticides enter their bodies in three ways: by swallowing, by breathing dust or vapors, or by absorbing through the skin. One form can prove just as toxic as the others, but most cases of poisoning occur through skin exposure; individuals may accidentally pour or spill the concentrate on their hands and clothing or they may be wetted with the spray mixture. On rare occasions, persons are poisoned by accidentally eating or drinking pesticide materials that have lost their labels or have been transferred to other containers such as beverage bottles. Unfortunately, children are the most frequent victims of such adult carelessness. Because of this, all pesticides should be kept in their original containers and locked up. If they cannot be locked up, they should be placed well out of the reach of children.

In the handling of any pesticide, 10 general rules apply. Applicators should:

1. Read carefully the label warning statement and directions for use on the container ***before*** beginning the operation; ***use only as directed***.
2. Wear rubber gloves when handling pesticide concentrates.
3. Wash hands before smoking or eating.
4. If clothing becomes saturated with liquid or dust, remove it immediately, take a shower or wash down with a hose, and change into clean clothes, including underwear.
5. At the end of each day's work with pesticides, always take a shower or bath and change all clothing.
6. Fill tanks and hoppers, treat seed, and make dilutions in well-ventilated places.
7. Leave unused pesticides in their original containers with the labels on them.
8. Triple-rinse pesticide containers, puncture to make unusable, and dispose of in an approved sanitary landfill. Paper containers may be burned, depending on local regulations.
9. Store pesticides out of reach of children and animals—preferably in a locked cabinet or storage room.
10. Not apply pesticides when weather conditions favor drift or near dug wells or cisterns.

Warning: Phorate, methomyl, carbofuran, ethion, fonofos, and mevinphos are very effective insecticides, but they are also highly toxic to humans if inhaled, absorbed through the skin, or swallowed. They should be applied only by certified applicators who have the experience, knowledge, and safety equipment necessary to protect all concerned.

SOURCES OF CONTROL RECOMMENDATIONS

By the time any publication on insect or plant disease control reaches the user, it has become outdated by more recent results of research, recommendations, and pesticide regulations. For a specific insect or a disease on a specific crop, the reader should consult more detailed information from reliable sources.

Insect- and disease-control suggestions come from many sources, but the most dependable are issued by the state agricultural experiment stations, the state cooperative extension services, and the U.S. Department of Agriculture. The cooperative extension service is represented by the county agricultural agents and the extension entomologist and plant pathologist. Most control suggestions can be obtained through the local county agent's office. USDA publications not available from the county extension offices can be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

SOURCES OF INSECT AND DISEASE IDENTIFICATION

Frequently vegetable producers find insects or diseased plants they cannot identify. These problems should be carried to the local county extension office or sent to the extension specialists located at the state university.

Insect pests, including immature stages if possible, should be carefully wrapped in soft tissue paper (soft-bodied insects such as caterpillars can be preserved in 70 percent isopropyl alcohol or rubbing alcohol), packaged in a small bottle, plastic box, or other strong container, and sent by First Class mail to the extension entomologist.

Plant disease specimens should include entire plants, when possible, with the roots wrapped in moist soil, peatmoss, or wet newspaper. They should then be carefully packed in a strong container and mailed First Class to the extension plant pathologist.

A letter should always be attached to the package describing the crop, area, fungicide or insecticide history, location, and type of damage. The more information given the specialist, the easier it will be to identify the specimens.

Note: Any suggestions made here for pest control are summarized from information available in publications of the U.S. Department of Agriculture and state agricultural experiment stations and are presented only as indications of current practices. Readers are reminded that any use made of the control measures suggested here are at their own risk, and they are urged to consult their local cooperative extension service or state experiment station for detailed information concerning the proper pesticides to use and the best ways to control insect and disease pests in their particular locality. Readers are also strongly urged to follow carefully the directions given by the manufacturer on the label of any pesticide to be applied.

SELECTED REFERENCES

In addition to the references listed below, the American Phytopathological Society (St. Paul, Minnesota) has published a series of compendiums of diseases of various vegetable crops, including beans, beets, cucurbits, lettuce, onions, peas, sweet potatoes tomatoes.

Agrios, G.N. 1997. *Plant Pathology*, 4th ed. Academic Press, San Diego, California.

Davidson, R., and W. F. Lyon. 1987. *Insect Pests of Farm, Garden, and Orchard*, 8th ed. Wiley and Sons, New York.

Foster, R., and B. Flood. 1995. *Vegetable Insect Management*. Meister Pub. Co., Willoughby, Ohio.

Hoffman, M. 1993. *Manual of Natural Enemies of Vegetable Insect Pests*. Cornell Univ., Ithaca, New York.