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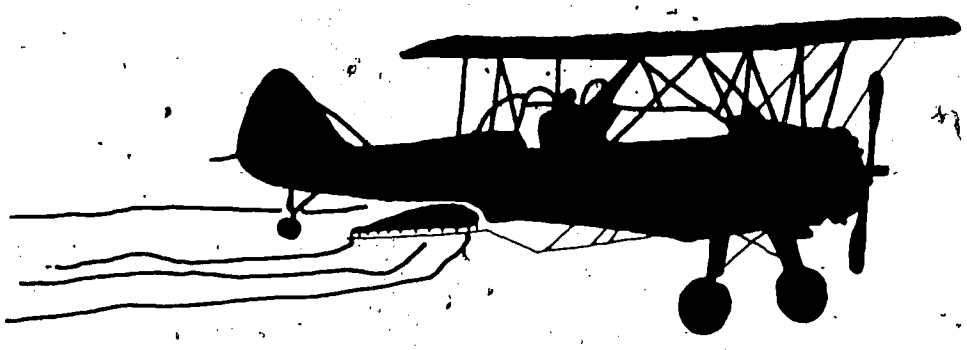
ABSTRACT

This manual is intended to assist pesticide applicators in the area of ornamental and turf pest control prepare for certification under the Michigan Pesticide Control Act of 1976. The three sections presented describe: (1) Ornamentals; (2) Turfgrass; and (3) Pest Control. Section one discusses the diagnostic chart for plant problems, non-pest injury, disease agents, weeds, insects and mites, and vertebrate pests. Section two discusses disease agents, weeds, insects and vertebrate pests. Section three discusses phytotoxicity, environmental concerns, protecting animals and people, application and area measurements. A list of self-help questions and instructions for completing the questions are presented at the end of each section. (HM)

Ornamental and Turf Pest Control



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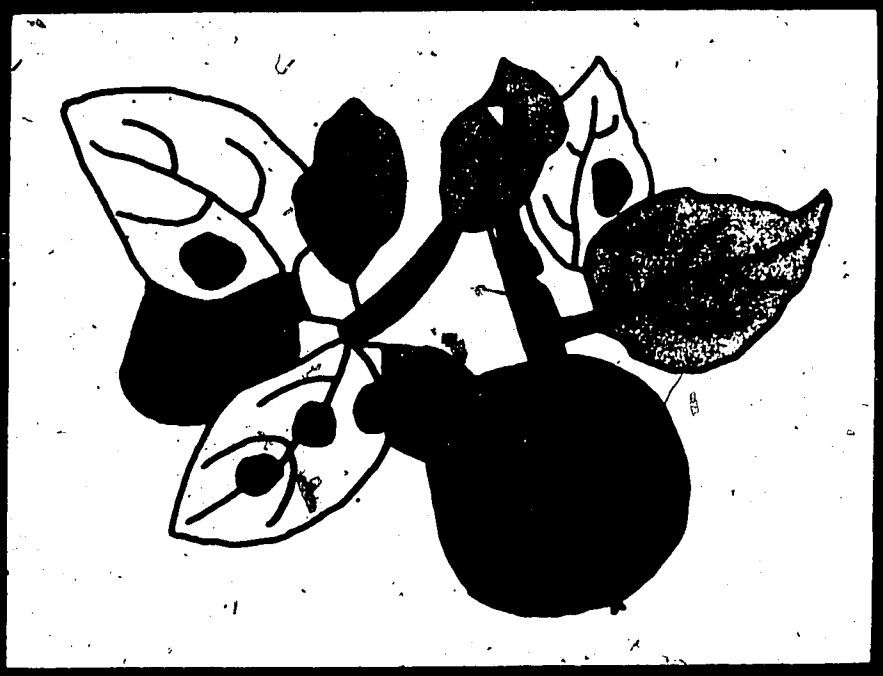
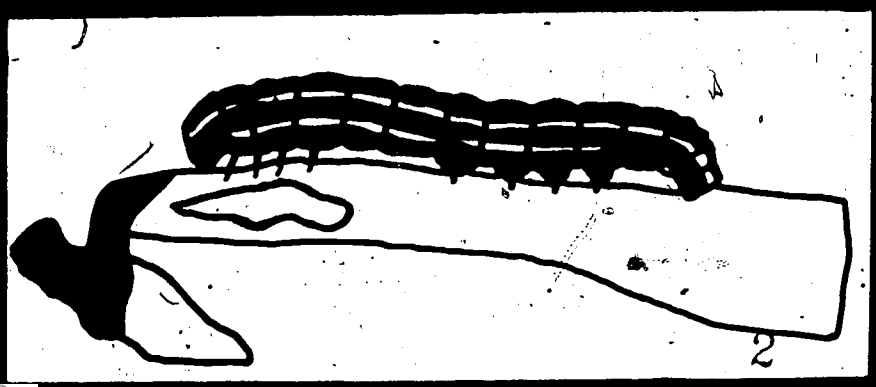
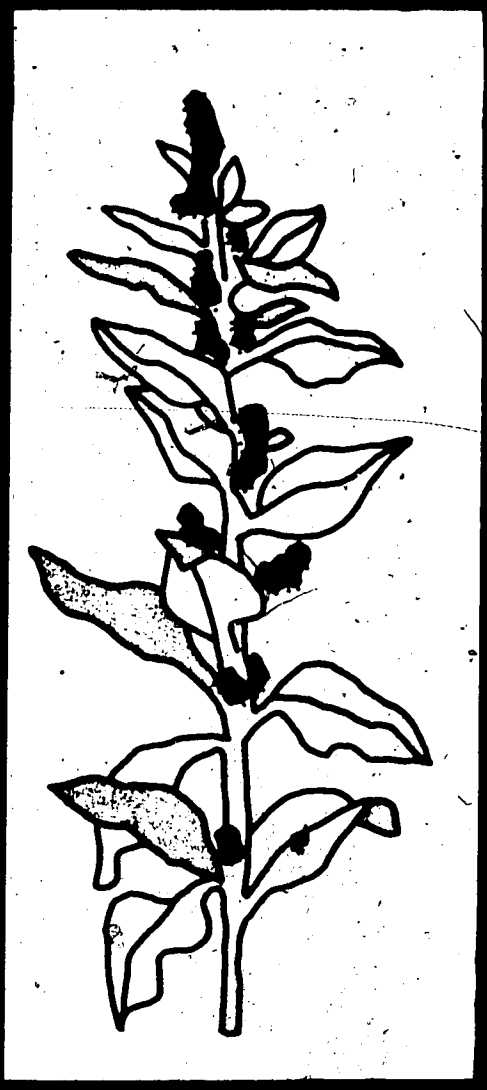
SAFE, EFFECTIVE USE OF PESTICIDES
A MANUAL FOR COMMERCIAL APPLICATORS







PREFACE

This manual is intended to assist pesticide applicators, in the area of ornamental and turf pest control, prepare for certification under the Michigan Pesticde Control Act of 1976. The manual was prepared by a group of specialists headed by Drs. D. C. Cress and C. H. Wamhoff of the Department of Entomology and Education Institute, respectively, of Michigan State University, with additional material from "Ornamentals and turfgrass pest control" by R. L. Robertson of North Carolina State University.

A list of self-help questions and instructions for completing the questions are at the end of each section. If you encounter difficulties in using the manual, please consult your county agricultural extension agent or representative of the Michigan Department of Agriculture for assistance.

Some suggestions on studying the manual are:

1. Find a place and time for study where you will not be disturbed.
2. Read the entire manual through once to understand the scope and form of presentation of the material.
3. Then study one section of the manual at a time. You may want to underline important points in the manual or take written notes as you study the section.
4. Answer, in writing, the self-help questions at the end of each section. Instructions on how to use the self-help questions in your study are included with the questions. These questions are intended to aid you in your study and to help you evaluate your knowledge of the subject. As such, they are an important part of your study.

5. Reread the entire manual once again when you have finished studying all of its sections. Review with care any sections that you feel you do not fully understand.

This manual is intended to help use pesticides effectively and safely when they are needed. We hope that you will review it occasionally to keep the material fresh in your mind.

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Introduction

Some plant damage is caused by living pests, including:

-disease agents

-weeds

-insects and mites, and

-vertebrate animals

Other causes of plant problems are:

-too little, too much, or imbalanced fertilizer

-pesticide injury

-improper planting and pruning

-root girdling

-soil conditions (such as improper drainage, compaction)

-mechanical damage (by such things as earth-moving equipment, mowers, and hand tools)

-pollution damage, and

-natural aging of plants (often mistaken for damage caused by insects and diseases)

You must diagnose the problem before using control methods. Can you find an insect or recognize the symptoms of a disease? Pinpointing causes of plant damage usually requires close observation.

DIAGNOSTIC CHART FOR PLANT PROBLEMS

Plant Part	Symptom	Possible Causes & Reference
Whole Plant	Recently transplanted plant fails to grow	Drought - Excess water - Injured prior to planting - Insufficient root system -
	Sudden death of growing plant or plant parts	Disease - Excess fertilizer - Gas - Girdling - Lightning - Weed killers -
	Gradual decline of previously healthy plant, poor growth, yellow and dropping of foliage, death of individual shoots	Air pollution - Construction - Disease - Drought - Excess moisture - Excess fertilizer - Gas - Girdling - Grade change - Insect injury - Nutrition - pH of soil -
Roots, main stem or branches	Malformation of growth	Insect injury - Weed killers - Disease -
	Die-back of shoots	Insect injury - Construction injury - Disease - Excess water - Girdling - Hail damage - Lack of light - Nutrition - Winter injury -
	Twigs or shoots with healthy leaves drop to ground	Insect injury - Squirrel damage -
	Bark splits on trunk	Lightning - Winter injury -
	Pitch on trunk or main branches	Insect injury -

Plant Part	Symptom	Possible Causes & Reference
Foliage	Scorched or dry appearance to foliage	Cold temperature - Drought - Excess fertilizer - Excess salt on foliage - High temperature - Nutrition - Physical injury - Spray injury - Nearby fire
	Foliage is yellow or mottled; may be less than average in size, distorted, drop prematurely	Air pollution - Disease - Excess water - Graft incompatibility - Improper pH of soil - Insect injury - Nutrition -
	Curled and distorted foliage	Insect injury - Weed killer injury - Disease -
	Wilted foliage	Disease - Drought - Excess fertilizer - Excess moisture - Gas leak -
	Skeletonized	Insect injury -
	Tunnels or mines between leaf surfaces	Insect injury -
	Chewed margins of foliage	Insect injury -
	Black or brown spotting of foliage	Disease - Spray injury -
	Gray color (sometimes bronze birch tint) to foliage, especially evergreens, webbing may be present	Mites - Air pollution -
	White leaves or powdery appearance to leaves	Air pollution - Disease (mildew) - Weed killer injury -

Plant Part	Symptom	Possible Causes & Reference
	Rolled leaves	Cold temperature - Drought - Leaf roller insects -
	Needles missing	Insect injury - Natural needle drop - Nutrition (lack of potassium) - Disease -
	Rusty areas on leaves	Disease (rust) -
	Black sooty appearance to leaves and stems	Insect injury -
Flowers	Plant fails to produce flowers	Improper daylength - Improper pruning - Juvenility - Nutrient imbalance - Shade - Winter injury -
	Fail to open properly	Drought - Insect injury - Spray injury - Winter injury - Disease -
	Petals chewed	Insect injury -
	Short flowering period	Drought - Temperatures unusually high and low humidity -
	Flower buds split	Herbicides - Moisture - Temperature -

NON-PEST INJURY

Could the plant have been injured prior to planting?

When a recently transplanted plant fails to grow and where the cause cannot be associated with drought, excess moisture, or insufficient roots, it is possible that the plant might have been injured prior to planting. It might have dehydrated while in storage or in transit, or it might have been subjected to an excessively high temperature.

Did the plant have sufficiently active roots to support the crown?

Plants that have been recently transplanted may not have a large enough root system to support the crown of the plant. Therefore, it is desirable to prune the crown of trees and shrubs that have been transplanted to help reduce the amount of transpiration during the reestablishment period. When pruning trees, do not cut the central leader, rather, thin out and help shape the tree or shrub in its natural form.

Sometimes trees are dug with a root system that is completely inadequate for the size of the plant. Such plants should not be accepted for planting.

Has there been a change in grade or some construction in the vicinity of the plants?

A change in grade (level of the soil) or some type of construction work in the vicinity of plants will change the soil environment which for some species of plants can result in their decline and eventual death. A few inches of clay fill over the roots of a beech tree or dogwood can be disastrous. Disturbing the roots of hard maples will often result in their showing early fall color and eventually the death of branches followed by death of the trees.

Is soil pH a cause of the problem?

Plants in order to make good growth should be grown in soil with an optimum pH (soil reaction). Most plants grow well in a pH range of 5.5 to 7.5. However, some plants such as blueberry and rhododendron require that they be grown in acid soils (pH 4.5 to 5.5). Other trees like the pin oak and holly will develop iron chlorosis when grown in alkaline soils (pH 7.5 to 8.5).

Are plants suffering from malnutrition?

Plants require certain elements which are essential for growth and proper development. A minimum supply of a particular element can cause the plant to be stunted, have yellow, mottled or scorched foliage and if completely lacking can result in the death of branches. Three of the more common deficiencies associated with ornamental plants are:

Nitrogen - Yellowing of the foliage. Although the entire plant may show the symptom, it will be expressed in the oldest leaves first.

Potassium - First expressed along the margins of the older leaves, which will become scorched. Older foliage will drop prematurely producing a leggy appearance.

Iron - Chlorosis is commonly associated with plants growing in soil with a pH above the optimum for that species. The symptom is a yellowing of the tissue between the veins while the tissue adjacent to the veins remains green.

Soil tests can be used to determine the levels and balance of the mineral elements in your soil. Application of the appropriate fertilizer can correct the deficiency. However, it should be recognized that similar symptoms may result from other causes and that fertilizer is not a panacea for all the ills of plants.

Has the plant been fertilized or has an excessive soluble salt condition developed?

Too much fertilizer, especially soluble forms, can cause problems in the growth and development of plants. Plants growing in containers (pots or planter boxes) without drainage holes can become the victims of a buildup of salt within the container. Plants exposed to either of these conditions will dehydrate. The rapidity of dehydration will depend upon the

concentration of 'salt'. The condition will develop slowly in containers unless fertilizer was applied, in which case the desiccation will be as rapid and injurious as too much fertilizer applied to plants in the garden. Always follow instructions when using fertilizer on plants and avoid growing plants in containers without drainage holes. If too much fertilizer has been applied, it might be leached out of the root zone by applying liberal quantities of water to the soil. Soluble salt problems can be confirmed by making a conductivity test upon a sample of soil.

Did the plant dehydrate due to lack of water?

All plants require some water and most plants require large quantities if they are going to grow in a normal manner. Although most plants receive adequate moisture as a result of rainfall or by artificial means, there are times when plants can dehydrate; particularly following transplanting or if they are growing in containers or in various adverse sites in a landscape (under building overhang). Follow transplanting, plants should be watered periodically until well-established. Plants in containers and in adverse sites should be watered on a schedule to assure adequate supplies of water for their growth.

Are the plants drowning?

Too much water about the roots of most plants used in the landscape can result in their decline and ultimately in their death. Plants require some oxygen in the soil for good growth and development. Planting sites should be well-drained or measures taken to artificially drain the site prior to planting. Rocks or gravel placed in the bottom of a planting hole will not function as adequate drainage. Drainage systems must be connected to free flowing drains to be effective.

Were the forces of nature the cause of plant injury?

The forces of nature can produce some dramatic forms of injury to plants. But they can also produce injury which is more subtle and more difficult to identify as to possible cause.

A. Lightning injury, although not too common, can be the most dramatic form of injury. Most trees struck by lightning, but not all, will have large areas of wood exposed with bark hanging in shreds. However, at times there may be no visible symptoms and the diagnosis may have to be made on circumstantial evidence, such as: was there a recent lightning storm and is it probable that the tree might have been struck? Trees struck by lightning may die within a few days or they may live for a number of years and then die or they may survive the strike and live to an old age. However, trees with exposed wood should be treated by an arborist. Valuable specimen trees should be protected by having lightning conductors installed in them by an arborist.

B. Snow that is wet and piles up on the branches of plants can cause damage in the form of breakage. A more subtle form of injury can result to broadleaved evergreens which are bent to the ground as a result of snow, recover in the spring but commence to die the following year. This delayed symptom is the result of physical damage done to the bark of the branches while under stress and snow. It can be prevented by providing some means of physical support prior to the onset of winter.

C. Hail causes physical injury to leaves and stems. In some cases, branches injured by hail may die.

D. The winter environment, especially late winter, can cause problems to many plants, including: freezing injury to buds and shoots, desiccation of evergreen foliage, and cracking of stems. Some evergreens (especially broadleaved evergreens) when exposed to the direct rays of the sun in late winter, while the ground is still frozen, will winterburn due to the lack of moisture or from extreme temperature changes.

E. Wind can sometimes cause serious problems to plants, particularly when it carries sand that abraids the stem, commonly at the ground-line. This form of injury can be prevented by maintaining a cover crop on the ground to stabilize the sand.

F. High temperature will often result in a short flowering period and if moisture is in limited supply will contribute to leaf scorch. Fire will scorch foliage and can destroy the cambium which will result in the death of plants.

Have the plants been injured as a result of a chemical?

Various types of chemicals applied to or drifting onto plants can cause injury or their ultimate death.

A. Air pollution. In industrial or large urban areas, air pollution can cause damage to sensitive species. In such a situation, the problem is widespread and not limited to a single yard but will cover a larger geographical area. Avoid planting sensitive species but better yet act to clean up the air.

B. Animal urine. Dog urine can be toxic to lawns and ornamental plants. Female dog urine can cause circular dead spots in the lawn and the urine of male dogs can cause unsightly brown areas on the lower portion of valuable evergreens. Cats confined to a small area can cause plants to decline due to the excess salt problem

which develops in the site where they urinate. Various repellents are available that are supposed to discourage visits by stray dogs. However, repeat applications are necessary.

C. Septic tanks. For years tree roots have been a problem to the proper functioning of drain fields. More recently, drain field effluent has been causing problems to trees. Borax and chemical agents used in laundry and cleaning products are leached into the soil where they cause injury to plants growing in close proximity to the drain.

D. Spray injury. Applying the wrong chemical or improperly applying a pesticide can cause injury to plants. The most common form of spray injury is leaf burn, particularly the margins or tip of the leaf. The propellent in aerosol sprays or the emulsifying agent can be responsible for injury to some plants. Dormant oils applied at the wrong time of the year or to sensitive species can also be responsible for plant injury.

E. Weed killers. If the new growth of plants is malformed and the leaves cupped and chlorotic (yellow or white), it is possible and highly probable that a weed killer, such as 2,4-D or dicamba has been applied in the vicinity of the plants. Some weed and feed lawn fertilizer contains dicamba, an excellend weed killer but it should not be applied above the root zone of valuable trees and shrubs. Spray application of 2,4-D type weed killers should be made only on calm days as certain formulations may drift onto valuable plants and cause various malformations of growth. Nonselective herbicides should be used with caution as they may wash into areas where they could kill valuable landscape plants. Spray equipment used to apply weed killers should not be used for other purposes.

Are pets or other animals responsible for the damage?

Animals of all kinds can cause considerable damage to plants. Canine urine is one of the more common animal problems. Girdling of the stems of plants by certain rodents is also common. In addition, rabbits can decapitate or chew the bard of young plants. Deer will eat the foliage, bark and tender shoots of plants. Other large animals can damage trees by clawing or rubbing the bark of tree trunks, chewing the foliage, compacting the soil (when confined to a small area) and by physically breaking the plants.

Much of this type of injury can be prevented by fencing out the animals or by applying various repellents to young plants, especially prior to the onset of winter.

Could a leaking gas line be the cause of death of the plant?

A leaking gas line can cause a rapid or the slow death of plants. If trees and shrubs have been growing vigorously for a number of years and then suddenly decline in vigor, even die within a matter of days, consider the possibility of gas injury to the plants if they are within 100 feet of a gas line. The gas company can check the area with a gas detection meter. However, before calling the gas company check for girdling roots, or other causes of the decline.

Is the plant being strangled to death?

A. A decline in vigor may be due to the girdling action of a wire or nylon rope encircling the stem or to the action of girdling roots or lianas of some vines. Nylon ropes used to secure the ball of soil during transplanting and guywires that supported newly planted trees should be removed when no longer needed. At the

time of planting, be sure that the roots are properly distributed in the planting site and that there are no encircling roots on plants that were produced in containers.

B. Plants can also be girdled by rodents. Rodents do most of their damage during winter months when they are short of their natural food supply. This form of damage can be minimized by the careful use of poison bait and keeping the area clear of weeds.

C. Many of the activities of man can also result in girdling valuable plants. Injury caused by mowers, "Lawnmower Blight", has increased considerably with the use of riding mowers. Cultivator or hoeing injury will often cause young plants to die. The activities of children with new hatchets sometimes results in the loss of valuable trees. This type of injury can be avoided by the proper use of equipment and the close supervision of children and employees.

D. Delayed graft incompatibility, although not a girdling action, is somewhat similar in end results. The union of some grafted or budded plants fails to function and the plants die. Very often this is preceded by a mass floral display. Inarching (grafting) can sometimes be used to safe a tree but normally when the condition is noted it is too late to inarch.

Does the plant fail to bloom?

A. Perennial plants will not bloom during their juvenile stage of growth, which for some species may be 8 to 10 years. Plants that are making rapid vegetative growth as a result of excessive application of nitrogen may fail to bloom. Some species of plants are biennial by nature; that is, they flower profusely every other year. In addition, environment plays an important part in the

flowering of many plants. Cold temperatures of winter may have frozen the flower buds or the plant may be sensitive to the length of the day, i.e. chrysanthemum and poinsettia.

B. Many plants bloom on wood produced the previous season; in pruning plants the flower buds may have been removed. Prior to pruning flowering trees and shrubs, study the flowering habit to avoid removing valuable flower buds.

C. Flower buds will split (blast) for a number of reasons, but most commonly the problem is related to temperature, moisture or both. Buds that develop the calyx during cold or dry periods will often result in flowers that blast when the temperature warms or the moisture stress is removed. The developing petals and pistils cause the calyx to split. Forcing plants into bloom in high temperatures can also cause splitting as is seen in lilies forced at too high a temperature. Growth regulators and weed control chemicals can also cause buds to blast. Do not apply herbicides in the vicinity of valuable plants. Plants grown from cuttings, grafts, or buds will flower more readily than seedlings, i.e. lilacs and wisteria.

DISEASE AGENTS

Fungi, bacteria, viruses, nematodes, mycoplasmas, and parasitic plants cause diseases of landscape plants. Most common diseases are caused by fungi. The environment is of major importance to the development of disease in woody plants. For example:

-A sudden drop in temperature in the fall or early winter increases the susceptibility of plants to cankers caused by fungi.

-Waterlogging of the soil contributes to the development of certain root rots.

-Long periods of rain can cause an increase of such fungal diseases as scab and leaf spots.

The more common diseases of landscape plants are described below.

Vascular Wilt

Vascular wilt fungi of shade trees are of two types:

-those that infect roots (Verticillium wilt), and

-those that infect stems (Dutch elm disease).

The organism that causes Verticillium wilt is present in the soil. It spreads upward from the roots through sapwood and interfers with water movement and other plant functions. Dutch elm disease is transmitted by elm bark beetles.

In both diseases, leaf wilting, browning between veins, and leaf drop usually begin in one branch and progress through the tree. Dead and dying branches, sparseness of the crown, and reduced twig growth are common symptoms. Another is a discolored streaking in the wood of affected branches or in the main trunk.

Leaf Spots

Fungal leaf spots occur on most kinds of ornamental plants. They usually appear first on the lower leaves. They may begin as dark brown, pin-head-sized spots which sometimes have a yellow halo. Spots may enlarge to cover an entire leaf. Small, black structures the size of pinheads are in the center of many leaf spots. As the spots become more abundant, leaves may yellow, die, and drop.

Leaf spots are more common in the early spring and fall. Wet conditions usually are necessary for infection. Healthy plants become infected when the fungus spores are:

-splashed onto them from infected leaves on the ground,

-blown to them by the wind, or

-carried to them on clothing and tools.

Scab

Apples, crab apples, and pyracantha are susceptible to the scab fungus. Symptoms include:

-spots on leaves and fruit, and

-premature defoliation.

Scab first appears as olive-green spots on the underside of new leaves. These spots become brown and velvety; then leaves turn yellow and drop prematurely. Fruit may become infected at any time with circular, olive-green spots that later become brown or black. The fungi overwinter in infected leaves and produce spores in the spring.

Powdery Mildew

Powdery mildew occurs on plants both in green-houses and outdoors. Common hosts are rose, zinnia, crab apple, euonymus, and crape myrtle. Powdery mildew may produce a white powdery coating on the leaves, buds, or stems of highly susceptible plants. The new growth is stunted and curled, and leaves may become dry and drop. The flower buds are often deformed and may fail to open properly.

Bacterial Fire Blight

Certain varieties of apple, flowering crab, pear, pyracantha, mountain ash, and quince are highly susceptible to fire blight. Hawthorn, rose, cotoneaster, spirea, and amelanchier are affected less seriously.

The signs of fire blight are:

-Blossoms and leaves suddenly wilt, turn dark brown, shrivel, and die, but usually remain attached.

-Secondary infections start in the small twigs, progress down the stem, and may involve whole branches.

-Blighted terminals may bend to look like a shepherd's crook.

-Dark streaking of the wood extends several inches beyond the diseased area.

-Cankers on limbs are shrunken, and are dark brown to purple. An orange gum or slime often oozes from them.

The bacteria overwinter in cankers on the plant. They are spread by:

-wind blown rain,

-insects, and

-pruning tools.

Nematodes

Many nematodes live in the soil and feed on plant roots. Some kinds cause small knots on roots; others kill the tips of feeder roots.

The above-ground symptoms of nematode damage may include:

-yellowing foliage,

-stunting, and

-a general decline of the plant.

It is difficult to distinguish between the symptoms of nematode damage and root rot infection. You may need to have soil and plant samples examined in a laboratory to confirm a nematode infestation. Root-knot of boxwood is an example of a nematode disease of ornamentals.

Disease Control

Types of chemicals available for disease control include:

-Protective chemicals applied to foliage, flowers, and fruit. They are subject to weathering and must be reapplied regularly.

-Systemic chemicals. These can be applied less frequently.

-Soil fumigants. Use of these to control soil-borne fungi, bacteria, and nematodes is economically feasible in the production and establishment of high-value ornamentals.

There are no known chemicals for control of virus. With few exceptions, disease-controlling pesticides will not eradicate disease-producing agents after infection has occurred. Careful management, including pruning out of dead and dying plant parts and the removal of infected leaves, coupled with preventive use of the correct fungicides and bactericides, will prevent further spread. In some situations, routine preventive use of a pesticide is the only practical way to protect highly susceptible plants. Your local extension agent can help you identify your pest problems and select the correct pesticide.

WEEDS

Many kinds of weeds are pests in landscape plantings.

Annual Weeds

Annual weeds are most troublesome in intensively cultivated ornamentals. Common annual weeds in ornamentals include:

-grasses (crabgrass, foxtailgrass, fall panicum, and barnyard grass) which germinate during the spring and summer

-annual bluegrass and annual bromegrass, which germinate during the late summer or fall,

-annual broadleaf weeds (purslane, pigweed, and lambsquarters) which germinate during the warm season and are killed by hard frost, and

-those that survive freezing temperatures (horse-weed, common chickweed, bittercress, and pepperweed).

Biennial and Perennial Weeds

Biennial and perennial weeds are most troublesome in uncultivated ornamentals. They have underground plant parts that survive from year to year. They are spread in several ways:

-Many spread easily when carried in soil, in root balls, and on cultivating equipment, as well as by seeds. These include Bermuda grass, Johnson grass, quackgrass, nutsedge, mugwort, and wild garlic.

-Seeds of perennial weeds such as dandelion and goldenrod are spread primarily by wind and water.

-Horsetail rush is spread by underground plant parts and by spores.

Weed Control

Consider both the weeds and the ornamental plants when choosing control methods. You can use cultural methods, mechanical methods, herbicides, or combinations of the three. Many weeds are resistant to some cultural or chemical controls. No herbicide is safe for all ornamental plants. Newly planted ornamentals usually are more easily injured by herbicides than established plantings. The label will tell you how to use a herbicide safely and effectively.

Herbicides kill weeds through the leaves or the roots or both. Selective herbicides kill some plants without killing others. Nonselective herbicides kill most plants in the area of application.

The main types of herbicides used in or around ornamentals are:

-preemergence herbicides,

-postemergence herbicides, and

-soil fumigants and sterilants.

Persistence varies with the herbicide and the dosage. Persistent herbicides may leave residues that may injure a sensitive crop planted later. Repeated applications of persistent herbicides also can injure ornamental plants under certain soil and climatic conditions. Granular formulations are an efficient way to apply preemergence herbicides. Postemergence herbicides usually are less persistent that preemergence herbicides. They usually must be applied as a directed spray.

Soil fumigants are nonselective and cannot be used in the root zones of desirable plants. Use fumigants before planting. The label will specify waiting periods between treatment and planting.

Soil sterilants will control most weeds for long periods of time. In humid regions, however, no material is completely effective for more than one season. Soil sterilants are nonselective. They can damage nearby trees, shrubs, and turfgrass through root uptake or movement of the chemical by wind or water.

INSECTS AND MITES

Ornamental plants are damaged by many kinds of insects and mites. Some suck sap from plants, others chew on or tunnel in plant parts or cause damage in other ways.

Some plants are very susceptible to insects and mites and require intensive pest control. Other plants are rarely attacked by insects or mites.

Pest insect infestations vary from year to year, and control is not always needed.

There are several kinds of insects and mites that you should recognize. They can be grouped according to the part of the plant they feed on and the kind of injury they cause.

Insects and Mites that Damage Leaves, Buds, Fruits, and Flowers

Caterpillars are the larvae of butterflies or moths. Caterpillars chew plant parts and may completely defoliate a plant. Some form webs or tents on the branches. A few bore into the plant and feed inside. Some have more than one generation per year.

Beetles are hardshelled insects. Many have spots, stripes, or other markings. Both adults and larvae may damage plant parts by boring into or chewing them. Some beetles are active only at night.

Leafminers are the larvae of small flies, wasps, moths, or beetles. They feed inside the leaf. Damage appears as brown or discolored blotches or winding trails on the leaf. They may be more than one generation per year.

Aphids are small, soft-bodied insects that suck sap through tiny needle-like mouthparts. There may be several generations in a single season. They may be green, red, or black. They feed on stems, terminals, or undersides of leaves. Foliage often curls or is otherwise distorted. Some aphids transmit plant disease. Aphids produce honeydew, a sweet liquid which collects on the foliage. A black sooty mold may grow on the honeydew. Sooty mold is controlled by controlling the aphids.

Mites are closely related to insects. They are hard to see without magnification. Eggs, young, and adults all may be present on an infested plant at the same time. Some form webs on the lower leaf surface. Mites damage leaves by sucking sap. The foliage becomes stippled and may turn off-green, yellow, or orange. Mites may produce several generations in a single season.

Lacebugs are small, broad, flat insects with clear, lace-like wings. Eggs, young, and adults all may be on a plant at the same time. Both adults and young suck sap and cause off-colored speckles, yellowing, and leaf drop. Many small, black, varnish-like spots of excrement on the undersides of leaves are evidence of lacebug infestation.

Insect Pests of Trunks, Stems, or Branches

Scale Insects and Mealybugs may kill large branches or whole plants. Some attack leaves and buds. Both insects secrete a protective waxy substance which covers them.

Mealybugs move on the plants as both young and adults. Newly hatched scale insects (crawlers) move around on the plant. Mature scale insects, however, are securely fastened to the plant surface. They may be circular, oval, or pear-shaped. Large numbers may form crusts on the plant. They lay eggs underneath the protective covering.

Borders are larvae of some moths and beetles. They do the most damage in the tissue just under the bark. Plants in poor health are more susceptible to attack by borers. One to several years may be required to complete a life cycle.

Insect Pests of Roots

Grubs are the larvae of hardshelled beetles or weevils. They usually are white with brown heads. Some have legs; others are legless. Grubs eat plant roots and may weaken or kill a plant.

Root Borers are the larvae of moths or beetles. They are shaped like grubs or caterpillars. They are usually a whitish color. Root borers damage plants by eating or hollowing out plant roots and crowns.

Root-Feeding Aphids weaken the root system of plants. They damage roots by sucking sap, which may cause galls to form. Root aphids look like foliar-feeding aphids. Some are serious pests of foliage as well as roots.

Galls are swellings of plant parts. Many kinds of insects and mites cause galls and live inside them. Galls are unsightly but usually are not harmful to the health of a plant.

Insect and Mite Control

To control insects and mites, direct the pesticide at the stage of the insect or mite that is causing the damage. In some situations, preventive use of insecticides may be necessary to protect plants from infestations. Your decision to use a preventive insecticide should be based on a previous history of infestation in your area. Your local extension agent can help to identify your pest problems and select the correct pesticide.

VERTEBRATE PESTS

Vertebrate animals may damage ornamentals in several ways. Some (such as mice and moles) feed on roots and crowns. Others (including mice, rabbits, deer, and woodpeckers) feed on stems, trunks, twigs, or foliage.

Barriers, trapping, repellents, and pesticides all help control vertebrate pests. Control of the insects on which vertebrate pests feed is essential.

SELF-HELP QUESTIONS ON ORNAMENTALS

Now that you have studied this section, answer these questions. Write the answers with a pencil without referring back to the text. When you are satisfied with your answers, see if you are correct by checking them in the text. Erase your answer and write in the correct answer if your first answer is wrong.

1. What could cause curled and distorted foliage of an ornamental?

2. What could cause rolled leaves of ornamentals?

3. What does disturbance of the roots of hard maples do to the tree?

4. What is the optimum range of pH for most plants?

5. How can the level and balance of fertilizers in a soil be determined?

6. How can excess salt be avoided in a soil?

7. When are plants particularly susceptible to dehydration?

8. How do rocks or gravel in a planting hole affect water drainage?

9. How does snow injure plants?

10. How can dogs be discouraged from urinating on turf and ornamentals?

11. Why are deer sometimes problems in ornamentals?

12. What problem is indicated by a sudden decline in vigor or rapid death of a previously vigorous tree?

13. Why should wires or ropes encircling stems be removed when no longer needed?

14. What is the common cause of splitting (blasting) of flower buds?

15. What conditions favor the development of diseases or ornamentals?

16. Where is the organism that causes Verticillium wilt found?

17. Does wet or dry condition favor the development of leaf spot disease of ornamentals?

18. Where does the fungi of scab overwinter?

19. What is the characteristic sign of powdery mildew?

20. Can fire blight be carried from tree to tree by insects?

21. How can you positively distinguish nematode infestation?

22. What types of chemicals are used for disease control of ornamentals?

23. What are some common annual weeds of ornamentals?

24. How are biennial and perennial weeds spread from place to place?

25. Should soil fumigants be applied before or after planting?

26. What kinds of insects cause mines in leaves?

27. How do mites feed on plants?

28. Can adult scale insects move on the plant?

29. What causes galls on plants?

TURFGRASS

Introduction

Pest control in turfgrass includes:

-good cultural practices, and

-chemical pest control.

Turfgrass problems often result from causes other than pests. These other causes include:

-improper watering,

-improper fertilization practices,

-injury from pesticides,

-accumulation of excessive thatch,

-improper selection of turfgrass species,

-improper mowing height,

-poor root systems,

-soil that is either too acid or too alkaline, or

-an accumulation of soluble salts in the soil.

Be sure to consider these factors when diagnosing and treating turfgrass problems. The secton on "non-pest injury" in the discussion of ornamentals will aid in identifying some of these problems.

DISEASE AGENTS

The major diseases of turfgrass are caused by:

-fungi, which can cause root rots and foliar diseases, and

-nematodes, which feed on the roots.

Stands of diseased grass may look thin and unthrifty or contain streaks or circular patches of dead grass. Some of the more common diseases of

turfgrasses are:

Helminthosporium

Helminthosporium causes leaf spots and root rots. Spots on the leaves usually begin as small purplish, reddish-brown areas about the size of a pinhead. These enlarge to form tan to light-brown spots with reddish-brown margins. When the disease is severe, the spots girdle the leaves at the base and cause them to yellow. A severe infection may cause a general fading out of turfgrass. Helminthosporium diseases are more severe during long periods of wet weather. They develop best under high nitrogen fertilization.

Rusts

Symptoms are light-yellow flecks on the leaves. As these spots enlarge, the surfaces of the leaves rupture. Dry, reddish-brown pustules develop. At this stage, the spores readily rub off. The grass first becomes light yellow and then rapidly turns tan or light brown as the grass leaves die. Rusts develop best in moderate air temperatures. The disease is less severe on rye grasses grown under high nitrogen fertilization.

Pythium Blights

Pythium blights are among the most destructive turfgrass diseases. Grasses most commonly affected are bentgrasses, Bermuda grasses, fescues, and rye grasses. The disease is first seen as small, irregularly-shaped, watersoaked, greasy patches 1/2 to 4 inches in diameter. A cottony growth may be present early in the morning. Diseased areas may eventually range from 1 to 10 feet in diameter. Pythium blights develop best in warm, humid weather. They are most severe on grass grown under high nitrogen fertilization.

Rhizoctonia Brown Patch

Under conditions of close mowing, Rhizoctonia brown patch appears as irregularly shaped patches of blighted turfgrass that range in size from a few inches to 2 feet or larger. At first, the patches are purple-green in color. They then fade to a light brown. When the grass is wet, the diseased patches frequently have dark, purplish margins (smoke rings).

When high mowing is practiced, the leaves wither and rapidly fade to a light brown. The patches may be irregular and range up to 50 feet in diameter. Rhizoctonia brown patch develops best during long periods of humid weather. The disease usually occurs during hot weather (80-90 degrees F). Grass grown under high nitrogen fertilization is more susceptible to the disease.

Snow Mold

Pink and gray snow molds are turfgrass diseases that occur in cold weather. A snow cover creates an ideal situation for the diseases to develop, but they often occur in the absence of snow.

Snow molds are seen as small patches of tan to light-brown grass, 2 to 4 inches or larger. Pink snow mold spots usually are smaller than gray snow mold spots. With gray snow molds, hard, dark-red bodies are embedded in the leaves.

Slime Molds

Slime molds appear as dull-gray to light-blue masses of powdery growth on the surfaces of the leaves. They are most common during long periods of light rainfall. Although they are unsightly, they do not damage the grass. Controls are not necessary.

Fusarium Blight

Fusarium blight causes brown patches 1 to 3 feet in diameter. The patches are similar to those caused by other turfgrass diseases, but they have green tufts (frog eyes) in the center. Fusarium blight is most severe during periods of high day and night temperatures. Lush grass with an accumulation of 1 inch or more of thatch is highly susceptible to severe outbreaks.

Fairy Rings

Fairy rings are seen as circles of darker green, faster-growing turfgrass ranging from 2 to several hundred feet in diameter. They are often surrounded by mushrooms, toadstools, or puffballs. These fungi may prevent water from penetrating the soil.

Nematodes

Many kinds of nematodes feed on the roots of turfgrasses and reduce their vigor. Nematode injury may be confused with nutritional problems, insufficient water, compact soil, or any other factor which restricts root development.

Symptoms of nematode injury include:

-thinning or completely killed areas,

-pale green to yellow color,

-excessive wilting, and

-poor response to fertilization.

The best way to identify nematode problems is with a laboratory examination of soil or plants.

Disease Controls

Disease-producing agents in turfgrasses can be minimized and in some cases controlled through the use of good management practices. Turfgrass fungicides are available for use as preventive sprays or granules. When an outbreak of a disease agent occurs, apply preventive fungicides immediately. After infection has occurred, use a preventive fungicide to protect against future infection. Timing of protective fungicide applications should be based on a knowledge of:

-the life cycle of the fungus, and

-weather conditions that are best for its parasitic activities.

Preventive use of a fungicide is sometimes warranted when the location has a history of turfgrass disease. The routine use of fungicides can prevent disease outbreaks in turfgrass, but is an expensive and potentially harmful practice. Your local extension agent can help you identify pest problems and select the correct pesticide.

WEEDS

Any plant can be considered a weed if it is growing where it is not wanted. Bentgrass, for example, would be a weed in a bluegrass lawn. To plan a good weed control program, you must:

-identify the desirable turfgrass,

-identify the existing weeds, and

-know what other weeds are likely to become a problem.

Annual Weeds

Annual weeds complete their life cycle in less than one year. Because climatic conditions influence the timing of the life cycle, the correct

time for control varies from place to place, year to year, and from one species to another. It is often desirable to establish turfgrass in the fall so the freezing weather will control summer annual weeds. In established turfgrass, the chemical control of summer annual weeds after midsummer may not be necessary or desirable.

Summer annual weeds common to turfgrass are:

Broadleaf Weeds	Grass Weeds
henbit	crabgrass
knotweed	goosegrass
spurge	barnyardgrass
	foxtailgrass
	stinkgrass

Winter annuals are common in new turfgrass. After the first year, good management and dense turfgrass usually provide satisfactory control. Examples are:

Broadleaf Weeds	Grass Weeds
common chickweed	cheat
shepherspurse	

Biennial Weeds

Biennial weeds normally occur at the same time as perennial broadleaf weeds. Controls are similar. Examples are: roundleaf mallow and wild carrot.

Perennial Weeds

Perennials, both broadleaf and grasses, occur widely as turfgrass weeds. Examples are:

Broadleaf Weeds	Grass Weeds
dandelion	Bermuda grass
wild garlic	bentgrass
dichondra	tall fescue
plantain	quackgrass
mouse-ear chickweed	nimblewill
red sorrel	torpedograss
	nutsedge

Weed Control

The presence of weeds in turfgrass does not always require the use of herbicides. In areas that contain sensitive plants, it may be better to avoid the use of herbicides than to risk injury. In some locations, any kind of plant cover may be better than dead plants or bare ground.

Granular formulations are effective for preemergence herbicides. Sprays are better for postemergence control where foliar coverage is needed.

Broadleaf weeds - Several postemergence herbicides are used to selectively control annual, biennial, and perennial broadleaf weeds in turfgrasses. They can be used alone or as combinations of more than one active ingredient. Spring and fall applications of postemergence herbicides normally give satisfactory control and reduce the possibility of damage to nontarget plants. Young weeds are usually more susceptible to herbicides. Spot treatments are best for scattered weed populations. Weather conditions affect control results.

Grass Weeds - Control of annual grasses is best achieved with:

-preemergence herbicides for general infestations,

-spot treatment with postemergence herbicides for localized infestations.

Few herbicides are safe for use on newly seeded turfgrass. Some preemergence herbicides applied in the spring adversely affect germination of turfgrasses seeded in the fall. Certain varieties of turfgrasses are more prone to injury by some berbicides. Check labels for precautions.

Perennial grass weeds are the most difficult to control. No herbicides are available which will control these weeds without damaging cool season turfgrass. Some will selectively control them in warm season turfgrass. Soil fumigants and nonselective herbicides are sometimes used.

INSECTS

When examining turfgrass for insects, look for:

-thinned grass stands,

-dying or dead patches,

-discolored or withered blades,

-chewed or frayed blades,

-frass or webbing,

-small holes, mounds, or burrows, or

-presence of large numbers of bird and animal droppings.

Some of the more troublesome turfgrass insect pests are:

Grubs

Grubs are the larvae of hardshelled beetles. They are white to off-white with a brown head and six legs. Grubs damage grass by eating the roots. Seriously damaged turfgrass can be rolled back like a carpet. When the grass is rolled back, grubs may be found lying in a C-shaped position in the soil. Grubs are most easily controlled during the time they are actively feeding.

Billbugs

Billbugs are small, dark-colored beetles with snouts. Adults lay eggs in turfgrass items in late spring. The eggs hatch into legless larvae. The larvae eat their way down the stems and into the crowns. Adults feed on leaves and stems, but cause less damage than the larvae. Damage shows up in late summer as small dead patches of turfgrass. Damaged plants break off at the crown if pulled on.

Sod Webworms

Sod webworm caterpillars are 1 inch or less in length. They are off-white with parallel rows of small dark spots. The adults are cigar-shaped, buff-colored moths. The caterpillars chew off grass stems and leaves above the soil line. Damage shows up as small dead spots. When many sod webworms are present, the spots join to form large, irregularly shaped brown patches. Adult sod webworms do not damage turfgrasses.

Insect Control

Insects that attack turfgrass at or below the soil surface can be controlled only by directing the pesticide at the soil surface and watering it in to contact the pests. Foliage-feeding insects can be controlled by directing the insecticide at the turfgrass foliage.

Watering in an application directed at foliage feeders will move the insecticide below the area where the insect pest is feeding and the desired control will be lost. In some areas, preventive applications of insecticides will minimize damage from soil insect pests. More than one pest may be causing damage at the same time. Each may require different timing and placement of insecticide for control. Be sure to consider this when you develop a treatment schedule. Your local extension agent can help you identify pest problems and select the correct pesticide.

VERTEBRATE PESTS

Vertebrate animals may damage large areas of turfgrass while they are searching for grubs or other soil-infesting insects. They include:

-mice,

-voles,

-skunks,

-moles,

-raccoons,

-foxes,

-squirrels, and

-birds.

Control of turfgrass-damaging insects also helps control damage by vertebrate animals, because it reduces their food supply.

SELF-HELP QUESTIONS ON TURFGRASS

Now that you have studied this section, answer these questions. Write the answers with a pencil without referring back to the text. When you are satisfied with your answers, see if you are correct by checking them in the text. Erase your answers and write in the correct answer if your first answer is wrong.

1. Does high nitrogen fertilization control Helminthosporium on turfgrass?

2. What disease causes dry, reddish-brown postules on grasses?

3. What are the distinguishing signs of Pythium blight?

4. Does Rhizoctonia brown patch generally appear during hot or cold weather?

5. Does snow mold develop in the absence of snow?

6. Are slime molds damaging to grasses?

7. What disease leaves green tufts (frog eyes) in patches of brown grass?

8. What organisms often surround fairy rings?

9. What other causes of grass problems may be mistaken for nematode damage?

10. What is a preventative fungicide?

11. Why is it desirable from the standpoint of weed control to establish a turfgrass in the fall?

12. What are some winter annual weeds?

13. Are perennial weeds common pests of turfgrass?

14. Are granular or spray formulations of herbicides better for postemergence weed control?

15. Are young weeds more susceptible to herbicides than older weeds?

16. When should spot treatment with a herbicide be used.

17. How do grubs damage turfgrasses?

18. When does damage of billbug appear?

19. Describe the caterpillar of the sod webworm.

20. Will watering in insecticides applied for foliage feeding insects aid in their control?

21. Does control of insects aid in the control of vertebrate pests?

Phytotoxicity

Phytotoxicity is undesirable injury to plants. Symptoms of phytotoxicity include:

-leaf drop,
-stunting,
-overgrowth,
-discolored foliage,
-leaf curl, and
-stem distortion.

The cause of phytotoxicity may be easy to determine or it may be subtle and hidden. Pesticides can cause phytotoxicity. Other causes that create similar symptoms are:

-insects and disease agents,
-insufficient moisture,
-improper fertilization, and
-other adverse growing conditions.

Factors that may contribute to pesticide phytotoxicity include:

-high air temperature during and immediately after pesticide application,
-excessive rates of pesticide application,
-too little water,
-uneven distribution of pesticide,
-mixing liquids or emulsifiable concentrates with wettable powders,
-mixing fertilizers with pesticides, and
-variety and species differences.

Take special care to avoid injury to landscape plants and turfgrass when using herbicides. Some herbicides leave residues in spray tanks that will injure desirable plants. Use separate sprayers for herbicides.

Environmental Concerns

To control drift and vaporization:

-apply pesticides when wind speeds are low,

-use lowest practical operating pressure and largest practical nozzle opening,

-keep nozzle as close to target as possible,

-avoid using airblast sprayers and dusters when working near sensitive plants and areas inhabited by animals,

-do not apply herbicides with airblast sprayers, and

-when possible, select products with low volatility.

To control the adverse effects of pesticide movement:

-use special precautions when using pesticides on slopes,

-select the least hazardous pesticide that will do the job,

-use the lowest effective rate of application,

-if possible, maintain a buffer zone between the area to be treated and sensitive areas,

-use mulches,

-consider the chances of heavy rainfall,

-regulate the amount and duration of irrigation

-be aware of the potential for ground water contamination, and

-avoid carrying treated material or the pesticide residue from the target area to other areas.

You must know the persistence of pesticides you apply to ornamentals and turfgrass, especially where:

-adjacent areas may be affected,

-treated soil is used to grow other plants, or

-humans, pets, or other animals are present.

Repeated applications of some pesticides to the same area may cause harmful residues.

Protecting Animals and People

Keep animals and people away during application and until spray has dried or dust has settled. Keep them away from areas of potential drift and runoff. Remove toys, pet food dishes, birdfeeders, and other articles from the site before applying a pesticide. Do not use pesticides when people or pets cannot be excluded during the reentry period specified on the label.

Application

Methods of application vary with:

-the kind of pesticide,

-the host, and

-the target pest.

Application equipment must be able to deliver a thorough coverage of the correct amount of pesticide to the plant parts which need protection.

Low-pressure, low-volume sprayers or granular applicators can be used for control of:

-soil or foliage pests of ornamentals,

-diseases or insects on turfgrass, or

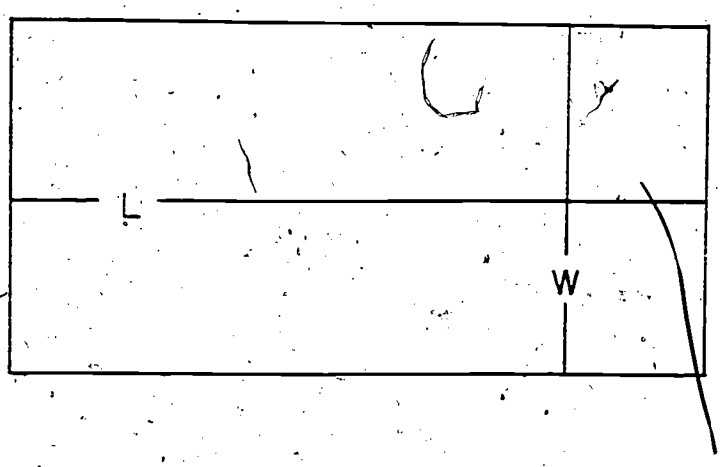
-weeds.

High-pressure hydraulic or airblast sprayers are not often used on ornamentals or turfgrass. You can use them for spraying large trees.

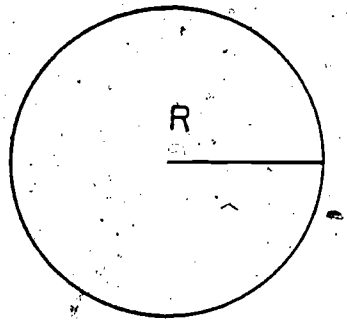
Area Measurements

To determine how much pesticide you will need to do a job, you must measure the area to be treated. If the area is a rectangle, circle, or triangle, simple formulas may be used.

Rectangles: The area of a rectangle is found by multiplying the length by the width. Area = Length x Width.

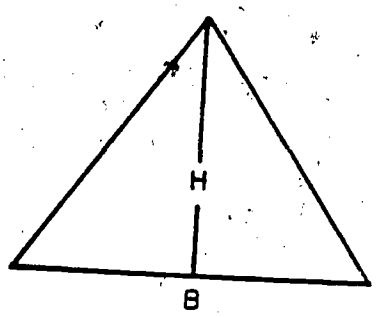


Circles: The area of a circle is the radius (one-half the diameter) squared and then multiplied by 3.14. Area = 3.14 x the radius squared.



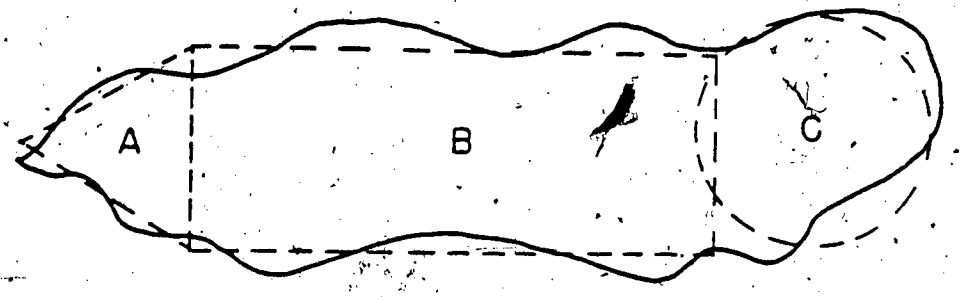
Triangles: The area of a triangle is one-half the base multiplied by the height.

$$\text{Area} = \frac{b \times h}{2}$$



Irregularly shaped turfgrass areas often can be reduced to one or more of these common shapes. Calculate the area of each and add them together to obtain the total area.

Example:

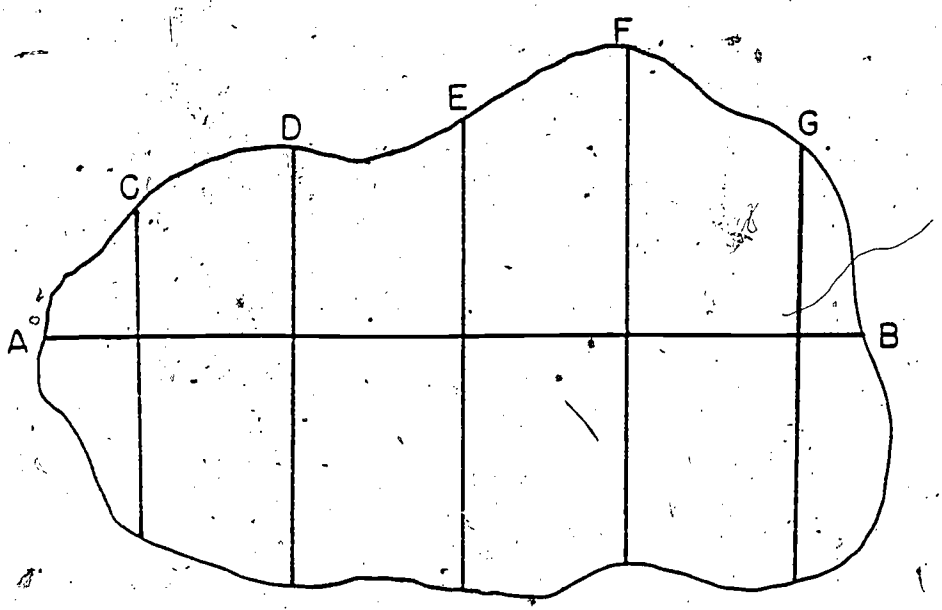


Area A + B + C = Total Area

Another way is to establish a line down the middle of the property for the length, and then measure from side to side at several points along this line. Areas with very irregular shape require more side to side measurements. The average of the side measurements can be used with the width. The area is then calculated as a rectangle.

Area = Length x Width.

Example:



Length = line AB

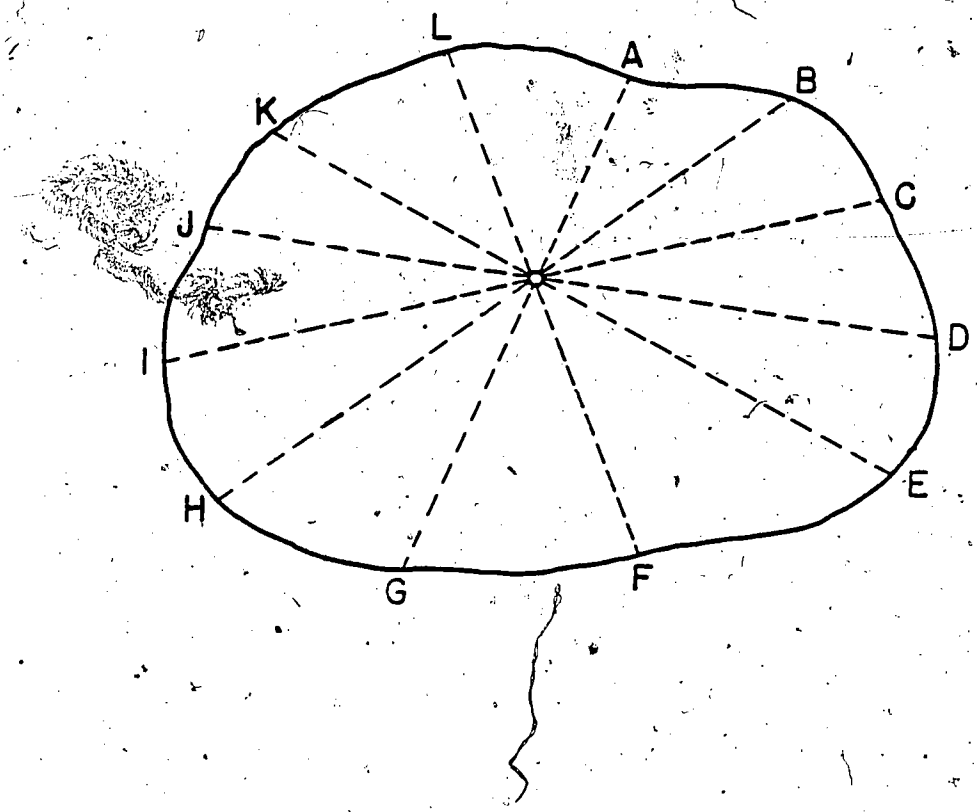
Width = $\frac{\text{line C+D+E+F+G}}{5}$

A third method is to convert the area into a circle. From the center point measure distance to the edge of the area in 10 to 20 increments. Average these measurements to find the average radius. Then calculate the area, using the formula for a circle.

Area = 3.14 x the radius squared

Example:

Figure 6



$$\text{Area} = (3.14) \times \frac{\text{line } A+B+C+D+E+F+G+H+I+J+K+L}{12}$$

SELF-HELP QUESTIONS ON PEST CONTROL

Now that you have studied this section, answer these questions. Write the answers with a pencil without referring back to the text. When you are satisfied with your answers, see if you are correct by checking them in the text. Erase your answer and write in the correct answer if your first answer is wrong.

1. What are some signs of phytotoxicity?

2. What are some means of avoiding drift and vaporization of pesticides?

3. What articles should be removed from an area before the area is sprayed?

4. What kind of equipment should be used to spray large trees?

5. What methods of measurement can be used to measure irregularly shaped areas?

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