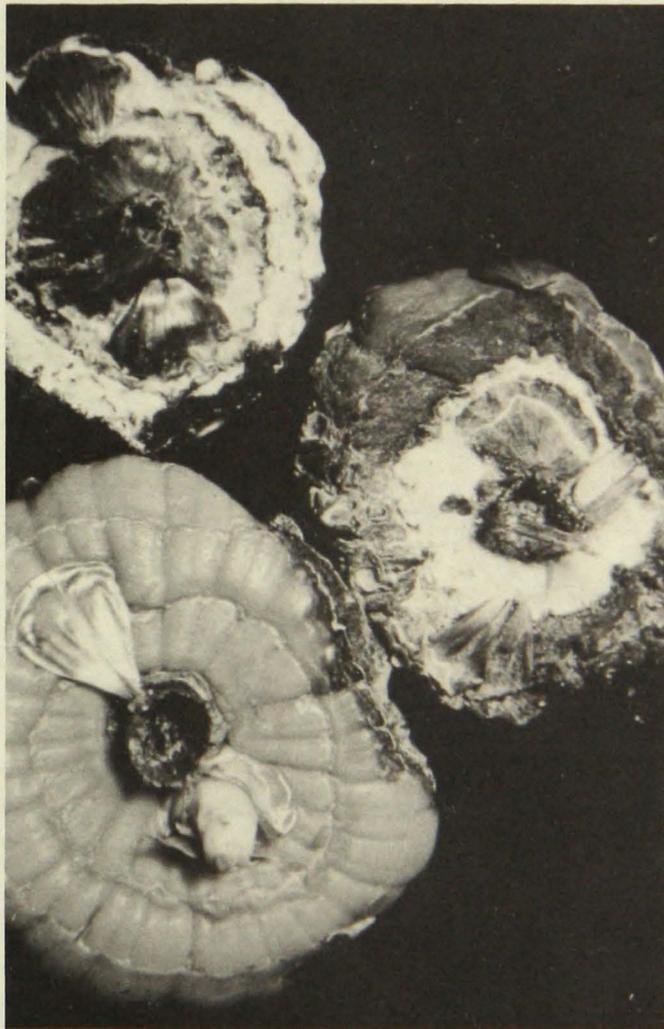


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DISEASE CONTROL IN THE FLOWER GARDEN

F.L. Pfleger

AGRICULTURAL EXTENSION SERVICE
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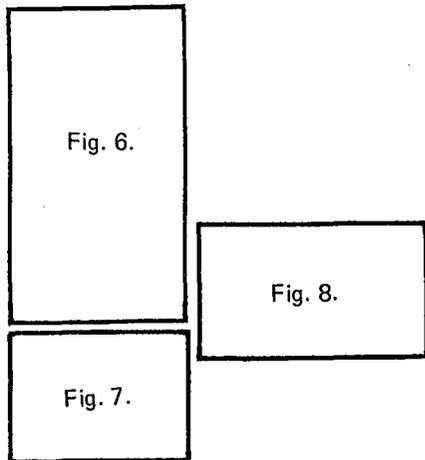


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COVER PHOTOGRAPHS

Fig. 6. Fusarium dry rot of gladiolus

Fig. 7. Rhizoctonia crown rot of delphinium

Fig. 8. Ring spot virus of dahlia

Table of Contents

Disease-Causing Agents3
 Bacteria3
 Fungi4
 Nematodes4
 Viruses4
 Nonparasitic Diseases5
 Plant Disease Clinic5
 Fungicide Selection and Handling5
 Fungicide Selection5
 Read the Label5
 Formulations of Fungicides5
 Names of Fungicides6
 Organic Fungicides6
 Handling Fungicides6
 Shelf Life of Fungicides6
 Fungicide Storage and Disposal6
 Fungicide Application7
 Method of Application: Dust or Spray7
 Equipment7
 When to Apply Fungicides7
 Amount of Fungicide to Use7
 Coverage7
 Rate7
 Spreader-Stickers7
 Seed Rot and Damping-off8
 Symptoms8
 Control8
 Seed Treatment8
 Additional Hints on Disease Control8

LIST OF TABLES

Table 1. Fungicides9
 Table 2. Disease Control of Various Flowers 13
 Table 3. Flower Seed and Planting Stock Treatment 19

DISEASE CONTROL IN THE FLOWER GARDEN

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Disease Causing Agents

Interest in home gardening has increased tremendously in recent years. Several factors have contributed to this interest. One is that more people have leisure time. Another is the desire to grow beautiful flower plants for use in landscaping designs or other projects. Of course there is always personal pride in growing the perfect specimen of a particular species.

Many novice home gardeners expect the same type of quality in their home grown plants as they find in commercial greenhouses. Oftentimes, they don't realize that quality plants produced by a commercial grower involve many factors such as type and amount of fertilizer, watering, disease control, and other variables. After a few years of gardening one learns to appreciate the amount of time and effort required to grow quality plants.

Disease control is an important factor which must be considered in producing flowers. It is not at all unusual to spend many hours throughout the summer caring for garden plants only to have the potential quality nullified by plant diseases. Disease problems can be of more importance to gardeners who specialize in one or more species of plants. The culture of the same plant year after year fosters disease problems, especially soil-borne diseases.

Several new fungicides have been developed which provide excellent control of certain diseases. Some of these compounds are specific, whereas other fungicides provide effective control of several different pathogens. However, the degree of disease control the gardener will obtain by fungicide application will be determined by correct diagnosis of the pathogen involved.

Plant diseases are caused by bacteria, fungi, nematodes, and viruses. A discussion of these disease-causing agents follows to help the gardener become familiar with some of the differences between these pathogens.

BACTERIA

Bacteria are very small micro-organisms, usually consisting of single cells. They multiply rapidly by the process of dividing in half. Occurrence of re-



Fig. 1. Damping off of a seedling

division may vary from 20 minutes to several hours. In some of the faster multiplying types a single bacterium could produce over 47,000,000 descendants in a 12-hour period.

Most bacteria are beneficial to mankind. About 170 different kinds of bacteria are capable of causing diseases on green plants. Bacteria cannot penetrate directly into plants. They must gain entrance through natural openings and wounds or by being deposited by insects during their feeding.

Unlike fungal spores, bacteria are usually killed by drying. Certain bacteria may remain alive in infected seed or storage organs, e.g., potato tubers or flower bulbs, for long periods of time. Bacteria may be transported quite readily by such carriers as insects, infested farm and garden machinery, tools, handling equipment, infected seed, and propagation stock.

Different species of bacteria affect plants in various ways. Their symptoms range from wilts and galls through rots and blights. Bacteria also produce toxins which are injurious to the plant. Control of bacterial diseases is through sanitation, seed treatment, application of fungicides and bactericides, and resistant varieties.

FUNGI

Fungi are low forms of plant life. These organisms cannot make their own food and therefore depend on other sources of organic material to provide their substance.

A fungus consists of a vegetative stage which appears as thread-like strands known as hyphae. Many fungi have a reproductive stage in which they multiply by means of small microscopic bodies known as spores. Spores function much like seeds of higher plants and may be dispersed by wind, water, insects, man, animals, or machinery.

Under favorable conditions, a fungus spore which lands on a susceptible plant can produce a new infection center. When the fungus spore germinates, it produces hyphae which may extend over the surface of the plant or penetrate directly into the plant tissue. Some fungi require openings such as wounds, abrasions, or natural openings (stomata) in the plant tissue to enter the plant. The fungus then is able to use the carbohydrates and other plant materials as food, thereby increasing its range of activity. At the same time, the by-products of the fungus are given off in the plant tissue, usually killing the plant cells or causing them to behave in an unnatural way. The result of this condition is recognized as a symptom of the disease condition.

Fungi may overwinter as weather-resistant spores or as vegetative mycelium in some form of decaying organic matter. When weather conditions become favorable, growth begins and a new infection process starts. Most common fungi grow best at relatively high temperatures and high humidities. Fungi are controlled by fungicide application prior to infection and by using resistant plants. Fungi cause root rots, leaf spots, cankers, and wilts.

NEMATODES

Nematodes are small roundworms. The nemas which attack plants are round, slender, thread-like worms about 1/50 to 1/25 of an inch long. Their mouth parts are usually equipped with a tiny spear mechanism that permits the nematodes to pierce the plant and thus feed. Some nemas may actually penetrate the root and feed internally; others may feed externally off the root.

The root knot nematode is probably the most commonly encountered nema. It causes a noticeable enlargement or swelling on infected roots, due to enlargement of the root cells.

Nematodes are usually introduced into a new area by the movement of infested plants, machinery, soil, or other agents.

Nematode infestations often result in such symptoms as yellowing of the leaves, stunting, hair roots, knots, swelling, or rotting of the root. Plants affected with nematodes may appear yellowish, stunted, and weak. Sometimes such symptoms are thought to be nutrient deficiencies. Nematode affected plants may not be able to withstand minor adverse conditions, such as drought or nutrient deficiency, as well as healthy plants. The leaves may be small and shed early. On below-ground plant parts affected by nematodes, there may be numerous hair-like roots, knots, and swellings.

VIRUSES

Virus diseases are caused by nucleoproteins produced only in the living cells of the host. Virus particles cannot be seen with an ordinary light microscope. Viruses do not penetrate plant tissue directly; they must enter through a wound or be transmitted by insects feeding first on virus-infected plants and then on healthy ones, or they can be transmitted by a person handling plants. Tobacco mosaic virus is found in smoking tobacco material. The hands of a worker smoking or handling tobacco may become contaminated, and the virus can easily be transmitted to susceptible plants as they are handled. Therefore, one should not smoke while working with plants.

Viruses often overwinter in the bodies of insects and in perennial weeds. Only a few viruses are transmitted in seed. Symptoms of virus-infected plants include mosaic patterns, stunting, dwarfing, veinclearing, streaking, and yellowing. The primary method of virus control is sanitation. Other methods include the use of resistant varieties, insect control, and the destruction of diseased plants.

NONPARASITIC DISEASES

Nonparasitic diseases are caused by environmental factors such as high or low temperatures, too much or too little moisture, or excess or deficiency of nutrients. In other words, conditions for plant growth are not favorable. Examples of nonparasitic diseases include blossom end rot of tomatoes and tomato physiological leaf curl.

Plant Disease Clinic

Disease identification often becomes complex. Symptoms can be masked by various environmental factors. In many cases several pathogens may be involved, making it difficult to diagnose the problems. Your local county agent may be able to offer some assistance. In the event that an on-the-spot diagnosis is not possible, a portion of the diseased plant can be sent to the Plant Disease Clinic, Department of Plant Pathology, University of Minnesota, St. Paul 55108.

Fungicide Selection and Handling

Obtain an expert's advice on your plant disease problem. Check with your county agricultural agent, the University Agricultural Extension Service, the person who sells pesticides, or any other knowledgeable person (not necessarily your neighbor) to see if a fungicide for your purpose is available.

When you select a fungicide to safely control disease, be sure to answer the following questions: (1) Has the cause of the disease been identified? (2) Does it cause a serious plant disease? (3) Are non-chemical control measures available? (4) How toxic (poisonous) are the suggested chemicals to humans

and the environment? (5) Will the chemical leave a toxic residue? (6) Are there any special health hazards to the applicator?

READ THE LABEL

After buying the proper fungicide and before using it, read everything on the label. When the container states that "more detailed information is available inside," open the container and read everything on the label. This is the best source of information on how to use that product. The label generally lists the plants on which the material can be used safely, the dosage required, and precautions to take while handling the fungicide. Pay particular attention to these items on the label: (1) warnings such as POISON, DANGER, KEEP OUT OF REACH OF CHILDREN, (2) specific directions on use, dosage, time, and methods of application, (3) crops that can be treated, (4) how to mix it, and (5) where and how to store or dispose of any leftover material.

Instructions on when the chemical cannot be used on food producing plants will be listed on the label also. If it states "no later than 14 days before harvest," do not pick the fruit or vegetable until at least 14 days after the last spray application. This is to insure that chemical residues will not be on the food when consumed.

FORMULATIONS OF FUNGICIDES

Fungicides are formulated as wettable powders, dusts, emulsifiable concentrates, granules, and aerosols

Wettable Powders

Most fungicides are formulated as wettable powders. They are easily wetted and disperse well in water. They also contain a wetting agent that allows for uniform spread and distribution of the fungicide on the plants. Since wettable powders do not form a solution, agitate the mixture frequently.

Emulsifiable Concentrates

These are liquid fungicides with the active ingredient dissolved in a solvent. When added to water, the emulsifiable materials form a milky mixture that is a suspension of active ingredient plus emulsified solvent in water.

Dusts

These are fungicides that have been ground into fine dust particules. They usually contain from 4 to 10 percent active ingredient. The fungicide is applied in the form of a dust.

Flowables

These are closely related to wettable powders. A flowable contains technical fungicide and flowable material, both of which have been ground to very fine dimensions and suspended in a small amount of liquid.

Aerosols

The fungicide is stored in a container under pressure. A propellant forces the mixture into the air as tiny droplets that are dispersed in the air and on the plants. Aerosols are used mostly in greenhouses.

NAMES OF FUNGICIDES

Names of fungicides can be confusing. For example, a fungicide can contain the same active ingredient and yet be sold under several different trade names. Note that fungicides listed in Table 1 include common name, trade names, and active ingredient. Before purchasing any fungicide, make sure it's the one needed to do the job. You can make sure by comparing common names, trade names, and active ingredient.

ORGANIC FUNGICIDES

Prior to the mid-1930s fungicides used in disease control were inorganic materials, i.e. sulfur, coppers, etc. In the late 1930s organic fungicides were developed and have since replaced many of the inorganic materials. In general, organic fungicides are less injurious to plants than inorganic compounds and provide better disease protection. However, organic fungicides usually require more frequent applications than, for example, copper fungicides.

HANDLING FUNGICIDES

Follow certain procedures when handling fungicides (or insecticides and herbicides) to use them properly and safely. Most fungicides are poisonous to humans and animals, as well as to plant disease-causing micro-organisms.

Hints for handling fungicides:

1. Wear protective clothing (rubber gloves, apron, and face mask) when the label requires them.
2. Don't inhale the dust when measuring or mixing.
3. Don't smoke when mixing or applying fungicides.

4. After equipment and fungicides are safely stored, wash yourself thoroughly with soap and water.

5. If you accidentally spill any fungicides on exposed skin, wash immediately.

SHELF LIFE OF FUNGICIDES

If fungicides are stored under dry, above-freezing conditions with the container properly closed, they will retain their effectiveness for 2 years. Purchase only the amount of fungicide that can be used readily in a couple of growing seasons, thus eliminating the need for long-term storage. A few hints which may indicate the ineffectiveness of a fungicide kept under storage are listed below:

<u>Formulation</u>	<u>Symptoms of Ineffectiveness</u>
Emulsifiable Concentrates	Milky formation does not occur when water is added or if separation layer is noted.
Wettable Powder	The fungicide will not suspend in water but rather lumps together.
Dusts	Reaction same as wettable powder.
Aerosols	Generally quite effective unless can's opening is damaged or obstructed in some way.

FUNGICIDE STORAGE AND DISPOSAL

Fungicides should be stored in the original package with the label preserved. The label will (or should) indicate how long that material can be stored, so write the purchase date on the package. Keep fungicides in a locked cabinet where only responsible persons have access to them. The cabinet should be high enough that children cannot get into it even if you forget to lock it. Keep fungicides dry and away from stored weed killers, whose fumes may contaminate the fungicide. Follow the label instructions for disposal. Never re-use pesticide containers for any purpose.

Chemicals used in plant disease control practices are listed by common name and trade name followed by a few examples of ornamental and vegetable crops. This indicates that the fungicide is registered for use on those crops. In most cases, many specific fungicides can be used on several additional crops. **CAREFULLY** read the label to determine fungicide use on other crops.

Fungicide Application

METHOD OF APPLICATION: Dust or Spray

The method by which fungicides are applied (spray or dust) often depends on the disease involved, environmental conditions, and the equipment on hand. Both the spray and dust will provide good control if applied properly. Sprayers are generally preferred to dusting for large acreages. Sprays can be applied in a slight breeze and must be applied before heavy dew or rains. It is often necessary to repeat an application after a heavy rain. When using a small manual sprayer, you can easily apply the spray material on the under leaf surface. If a wettable powder is used, the solution must be agitated to prevent the material from settling out. Sprayers must be washed out thoroughly after each use.

Dusts are much easier to apply on garden plants, and dusters do not have to be cleaned out after use. However, dusts tend to deposit a dull film on foliage and flowers and they must be applied when there is no wind. Leaf surfaces should have a slight amount of moisture on them in order for the dust to adhere to the leaf surface.

EQUIPMENT

Most home gardens are quite small and require limited, inexpensive disease control equipment. There are small power sprayers and power dusters available for fungicide application on larger plots. Sprayers and dusters must be kept clean and maintained in good operating condition.

Regardless of the type and size sprayer or duster, they must have sufficient force to drive the fungicide into the center of the foliage as well as providing good distribution. Sprayers which deliver a fine droplet size provide more uniform coverage than large droplets. Frequent agitation of the spray suspension is required to prevent the fungicide from settling out in the spray tank.

Sprayers used for weed control should not be used to apply insecticides or fungicides. Herbicides are very difficult to remove from a sprayer. Therefore, it is advisable to have two separate sprayers—one for insecticide and fungicide application and one for herbicide application. These sprayers should be identified in some manner to avoid any mistakes.

WHEN TO APPLY FUNGICIDES

Effective disease control usually requires regular treatment intervals of 7 to 10 days. Fungicides lose their effectiveness and break down due to such factors as watering, rain, and ultraviolet light. As the plant produces new leaves, they also must be protected by spraying at regular intervals. Most fungicides are preventive, not curative. In other words, they must be applied before the disease is present to protect the plant or applied immediately when the first signs of disease appear. In recent years new systemic fungicides have been developed which are both eradivative and curative.

AMOUNT OF FUNGICIDE TO USE

Often several fungicide applications are necessary to control a plant disease, whereas in other cases only one application is required. Note that in disease control recommendations, several different fungicides may be used to control a disease. The gardener is encouraged to use any one of the recommended fungicides on hand, unless a specific fungicide is mentioned.

The amount of fungicide to use can be found in Table 2 with the control measures recommended for the floral diseases discussed. All recommendations have been converted to tablespoons or teaspoons per gallon of water. The proper concentrations will result in a fungicidal solution that will provide satisfactory disease control when applied properly and used according to directions.

COVERAGE

Uniform application of the fungicide is required if good disease control is to be expected. This is true for sprays and dusts. It is important to apply the materials at the proper rates and to cover plant tops and undersides of leaves.

RATE

Years of trial studies have been conducted to determine the most effective rate of fungicide application for disease control. Too much fungicide may result in toxicity to the plant. If less than the recommended amount is used, then satisfactory disease control will not be obtained.

SPREADER-STICKERS

Spreaders and stickers are materials which, when added to fungicides, provide greater spreading action on leaf surfaces that are difficult to wet (for example

gladioli, rose, etc.) and provide for better adherence to plants for longer time periods. Some commercially available spreader-stickers include: DuPont Spreader Sticker, Film Fast Spreader Sticker, Triton B-1956, Ortho Spreader Sticker, and Biofilm.

Seed Rot and Damping-off

SYMPTOMS

When seeds are planted in infested soils, damping-off fungi may attack them at any stage. The damping-off fungi may attack the seed prior to germination, or they may attack after the seed has germinated but before the seedling has emerged above the soil line. An infected seed becomes soft and mushy, turning a brown-to-black color, and it eventually disintegrates. Seeds that have germinated and become infected develop water soaked spots which enlarge and turn brown. The infected tissue collapses, resulting in death of the seedling (fig. 1). Penetration and death of seeds before they emerge is termed preemergence damping-off.

Seedlings that have emerged are usually attacked at or below the soil line. The organism can easily penetrate the young soft stem tissue. The infected stem portion becomes discolored and begins to shrink. As this occurs, the supportive strength of the stem's invaded portion is lost, and the seedling topples over. The fungi continue to invade the remaining portion of the seedling, resulting in its death. This phase of the disease is termed postemergence damping-off (fig. 1).

Older established plants also can be attacked by damping-off fungi. Usually the new developing rootlets are infected, resulting in root rot. Infected plants show symptoms of wilting and poor growth.

CONTROL

Proper conditions for seed germination and seedling emergence also favor vigorous growth of fungi that cause damping-off. Seed and roots must be kept moist and warm until the roots have penetrated the soil and the seedlings have emerged. As the seedlings continue to grow, moisture at the soil surface can be decreased, and the damping-off fungi then will have less of an advantage. When watering, thoroughly saturate the soil and then apply no more water until soil approaches the point at which plants wilt. This procedure will keep surface soil dry a maximum time. Avoid frequent sprinkling, because this generally keeps surface soil too moist and promotes fungal growth.

Damping-off may not occur at a given location for many years and then be devastating in one season. Such situations sometimes can be traced to a change in crops or plant varieties, a change in source of soil, or some change in cultural practice. Before any changes are initiated, it would be wise to test the intended changes on a small scale before the main planting is done.

Control measures for damping-off fall into several categories, depending upon the facilities available and whether preventive measures are to be used after the trouble has begun. Preventive measures are much preferred, but make preparations for emergencies. Preventive measures are based on eliminating fungi that cause damping-off or providing chemical barriers to prevent the fungi from growing.

The home gardener can purchase sterilized, packaged soil mix from many garden centers and use the mix for potting or preparing flats for direct seeding. If a homemade soil mix is preferred, it must be pasteurized prior to use. This can be accomplished by placing the soil in shallow containers (2 to 3 inches deep), putting them in an oven, and maintaining a temperature 375° F for 35 minutes. To prevent soil recontamination, all items such as tools, pots, flats, etc. must be clean. These items can be cleaned in hot water (160° F for 30 minutes) or in a chlorine bleach solution (1 part bleach to 9 parts water; soak for 30 minutes). It is important to use fresh chlorine bleach: water solutions.

SEED TREATMENT

Seed should be coated with a protective fungicide even though the soil has been disinfected. There is always the possibility of recontamination of pasteurized soil. Seed treatment fungicides help protect seeds from seed-rot and soil-borne organisms. Seed treatment fungicides include Captan 75 and Thiram (Thiram SF75, Tersan, Arasan). A small amount of these fungicides can treat many seeds. Place the seed to be treated in a container and add the amount of material required (read label) to treat the seed. Then shake the seed: fungicide mixture until all the seeds are evenly coated.

Additional Hints on Disease Control

Fungicides must be thought of as an additional tool used to control plant diseases. However, there are other effective methods of controlling diseases which should be incorporated in a total program. These con-

tol measures are as follows: (1) plant when conditions favor the crop not the disease, (2) avoid crowding plants to provide for good air movement, (3) practice crop rotation with unrelated crops, (4) destroy diseased plants to prevent spread and build-up of the

disease, (5) plant resistant varieties whenever possible, (6) provide proper soil moisture and nutrients, (7) rake up and discard all plant debris in the fall as many pathogens are capable of overwintering in infected plant material, and (8) avoid early evening watering.

Table 1. Fungicides

Common Name	Use*	Active Ingredient	Sold As
Benomyl	sp	Methyl 1-2 benzimidazolecarbamate	Benlate, Tersan 1991, etc.
Bordeaux mixture	sp	A reaction product containing various copper compounds	Various trade names generally labeled as Bordeaux mixture.
Botran	sp	2,6-dichloro-4-nitroaniline	Botran 75W
Captan	sp, sd	N-trichloromethylmercapto-4-cyclohexene 1, 2 dicarboximide	Orthocide 50W, Captan 50W, Orthocide 75, Captan 75, etc.
Copper (fixed)	sp, so	A large group of various copper salts (copper oxychloride sulfate, basic sulfate, oxides, hydroxides, chlorides, etc.)	C-O-C-S, Kocide 101, Ortho Copper 53, Tribasic Copper Sulfate (53%), Miller 658, Cop-o-Zinc, etc.
Copper Sulfate		Copper sulfate (used in making Bordeaux mixture)	Comes in various forms of crystal, instant, snow, and powder (also known as blue vitriol, bluestone, etc.)
Cycloheximide	sp	Cycloheximide	Actidione, Actispray, Actidione PM, etc.
Chlorothalonil	sp	Tetrachloroisophthalonitrile	Daconil 2787, Bravo, etc.
Ferbam	sp	Ferric dimethyl dithiocarbamate	Fermate, Coromate (76%), Fermate Ferbam Fungicide (76%), Karbam Black (76%), etc.
Folpet	sp	N-trichloromethylthiophthalimide	Ortho Phaltan 50W (50%), Stauffer Phaltan 75W (75%), etc.
Karathane	sp	Dinitro (1-methylheptyl) phenyl crotonate plus related dinitro derivatives	Karathane WD
Maneb	sp	Manganese ethylene bisdithiocarbamate	Manzate, Dithane M-22, etc.
Mancozeb	sp	Zinc ion and manganese ethylene bisdithiocarbamate	Manzate 200, Dithane M-45, etc.
PCNB	so	Pentachloronitrobenzene	Terraclor 75%, WP, etc.
Spray Lime	sp	Calcium hydroxide	Sold as Hydrated Spray Lime.
Streptomycin	sp	Streptomycin	Agrimycin 17, Agri-Strep Type A, Phytomycin, etc.
Sulfur	sp	Sulfur (dust, wettable powder, and other forms)	Various commercial trade names and forms available
Thiabendazole	sd	2-(4-thiazolyl)-benzimidazole	Mertect 160 etc.
Thiram	sd sp	Tetramethylthiuram disulphide	Arasan 75, Thiram 75, Thylate, Thiram 75W, etc.
Zineb	sp	Zinc ethylene bisdithiocarbamate	Dithane Z-78, Parzate C, Stauffer Zineb, etc.
Ziram	sp	Zinc dimethyldithio carbamate	Zerlate, Ortho Ziram, etc.

*sp - spray or dust

sd - seed treatment

so - soil treatment

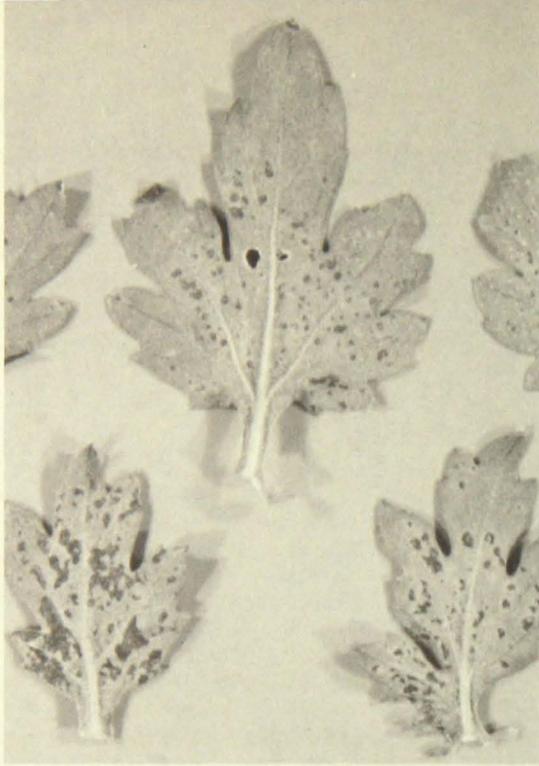


Fig. 2. Septoria leaf spot of chrysanthemum

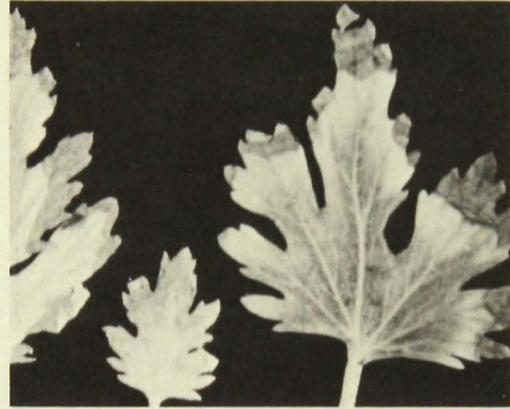


Fig. 3. Verticillium wilt of chrysanthemum



Fig. 4. Stunted chrysanthemum



Fig. 5. Mosaic virus of dahlia

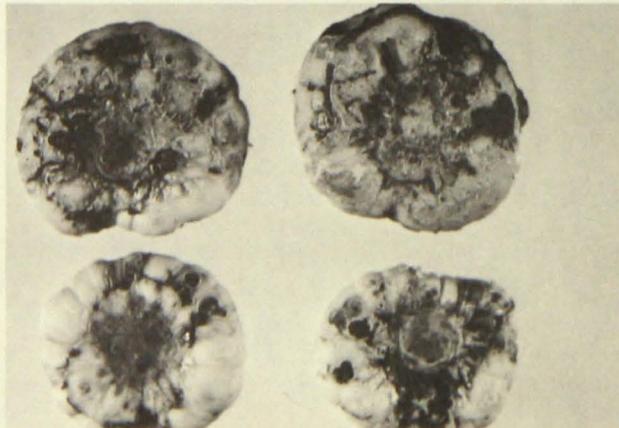


Fig. 9. Scab of gladiolus

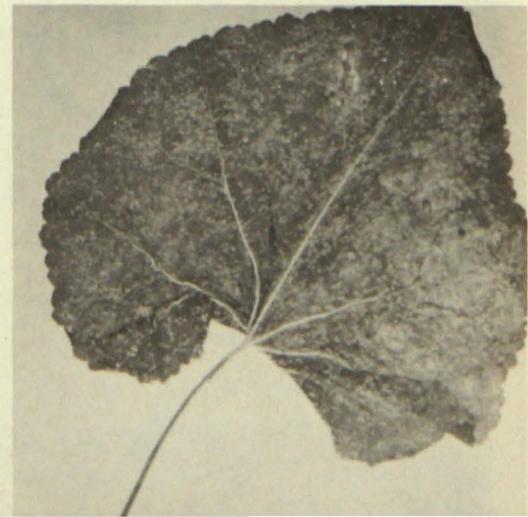


Fig. 10. Hollyhock rust



Fig. 11. Crown rot of iris

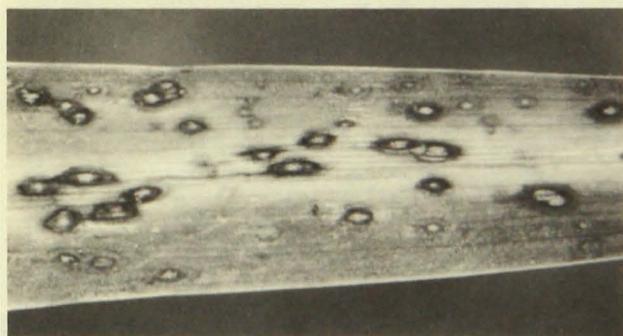


Fig. 12. Leaf spot of iris



Fig. 14. Botrytis blight of peony



Fig. 15. Phytophthora blight of peony



Fig. 13. Botrytis of pansy

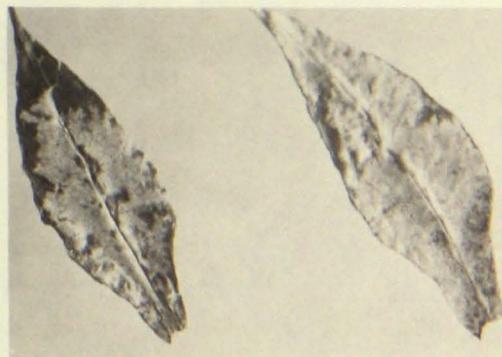


Fig. 16. Powdery mildew of phlox



Fig. 17. Black spot of rose



Fig. 18. Powdery mildew of rose



Fig. 19. Rose rust



Fig. 20. Botrytis blight of tulip

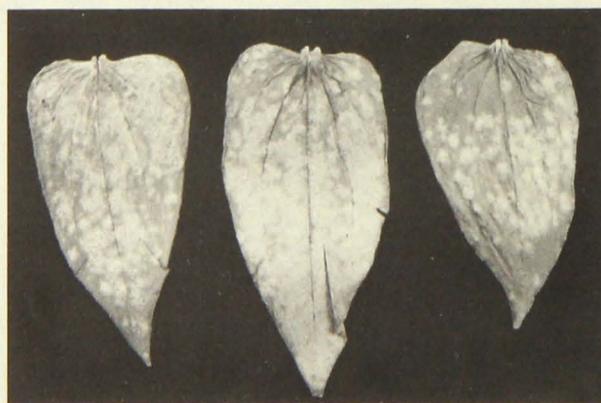


Fig. 21. Powdery mildew of zinnia



Fig. 22. Virus of zinnia

Table 2. Disease Control of Various Flowers

Plant	Disease	Symptoms	Control
Aster	Botrytis stem rot (fungus)	Gray spores appear on affected plant parts. The fungus causes a black rot on leaf and stems causing them to wilt.	Avoid crowding plants. Water early during the day. Spray with Maneb 1½ Tbs/gal every 7 to 10 days.
	Fusarium wilt (fungus)	Plants begin to wilt. Dark streak may be seen near base of stem, as well as a dark ring beneath stem tissue. Roots are underdeveloped and stunted.	Plant resistant varieties. Do not plant in same location each year.
	Yellows (mycoplasma)	Plants are stunted and distorted. Often-times flower color has a green cast and flowers open unevenly.	Remove and destroy infected plants. Grow plants under insectproof cheesecloth, 22 X 22 threads per square inch. Control weeds for they serve as hosts for mycoplasma. Use insecticides to control insects.
Azalea	Anthrachnose	Both leaf surfaces have numerous small, round, olive-brown to rusty brown spots. Heavy infections cause defoliation.	Spray weekly with Maneb or Zineb 1½ Tbs/gal.
	Crown rot	Brown discoloration in wood of main roots and basal portions of stems. Infected branches wilt and die.	Prune out infected branches; severely infected plants should be removed along with surrounding soil.
	Dieback	Terminal buds and leaves turn brown, roll up and droop. Stem shrivels above canker which encircles stem.	Prune out infected tip; after bloom spray with Bordeaux (2-2-50) and repeat in 10-14 days.
	Powdery mildew	White powdery growth on upper leaf surface.	Spray with benomyl or Karathane 1½ tsp/gal.
	Wilt and root rot	Foliage becomes a dull yellow and wilts. Roots are decayed and base of stem is brownish.	Plant in well-drained soils. Remove wilting plants from plantings.
Begonia	Bacterial leaf spot	Small, circular, blister-like spots on the leaves which gradually enlarge and coalesce to form dead areas. Stems may be invaded and eventually collapse.	Spotted leaves should be removed. Avoid wetting of the foliage and increase air circulation around plant.
	Bortytis - leaf blight and stem	Dead areas on leaves, stems and flowers often covered with brownish-gray mold.	Prune out infected portions and spray plant with Maneb 1½ Tbs./gal.
	Crown and stem rot	Crown and lower stems become discolored, water-soaked, and soft.	Destroy infected plants. Plant in well-drained soils.
	Powdery mildew	White powdery fungal growth on upper surface of leaves. Severe infections can cause leaf distortion.	Spray with Benlate or Karthane 1½ tsp/gal.
Chrysanthemum	Nematode-foliar	Portions of affected leaves turn brown where nematodes are feeding. As disease progresses, leaves die and fall. The small worms responsible for this disease cannot be seen with naked eye.	Plant only uninfected plants. Remove and destroy diseased plants. Do not plant mums in same area for at least 3 years.
	Septoria-leaf spot (fungus) (fig. 2)	Dark spots appear on lower foliage and increase in size as disease progresses. Within spots, small dark structures of fungus can be seen.	At first sign of the disease, begin to spray with Maneb 1½ Tbs/gal or Folpet 1½ Tbs/gal. Apply every 5 to 7 days. Practice a 2-year rotation program.

Table 2. Disease Control of Various Flowers

Plant	Disease	Symptoms	Control
	Powdery mildew (fungus)	A white powdery growth appears on the leaves causing leaf distortion. Fungus can infect blooms. Disease development is usually favored by cool moist environmental conditions.	At first sign of the disease, spray with Benomyl 1½ tsp/gal or Karathane 1½ tsp/gal or use sulfur 1 Tbs/gal. Sulfur can cause injury if temperature is 80° F or above.
	Rust (fungus)	Reddish spots about size of pinhead development on underside of leaf.	Remove and destroy infected leaves. Spray with Zineb 2 Tbs/gal or sulfur 2 Tbs/gal. Dusts can be used.
	Verticillium wilt (fungus) (fig. 3)	Lower leaves begin to wilt, turn yellow and then brown. Plants wilt during day and recover at night until disease becomes severe. Plants are stunted and fail to product flowers. If stem is cut off at base, dark ring can be seen.	Remove infected plants. Plant resistant varieties.
	Stunt and virus diseases (fig. 4)	Plants are stunted and often distorted. Virus cause premature flowering and abnormal plant color.	Use insecticides to control insects. Remove and destroy infected plants. Plant virus-free plants.
Dahlia	Botrytis-gray mold (fungus)	Fungus can attack leaves, stem, and buds. Gray masses of spores form infected tissue. Moist cool weather favors disease development. Fungus is often seen on dying petals.	Remove infected plant parts and destroy. Spray with Benomyl 1½ tsp/gal or Maneb 1½ Tbs/gal.
	Mosaic-virus (fig. 5)	Virus-infected leaves are mottled. Plant is stunted and bushy. Light green bands of leaf tissue can be seen along the midrib.	Remove and destroy infected plants. Control aphids. Plant tubers produced from healthy plants.
	Powdery mildew (fungus)	White powdery fungal growth on upper leaf surface. Leaf distortion and defoliation occur when infection is severe.	Spray with Benomyl 1½ tsp.gal or Karathane 1½ tsp/gal or spray with sulfur 1 Tbs/gal.
	Ring spot virus (fig. 6) (cover photo)	Affected leaves have light green spots. As disease progresses ring spots develop on infected leaves.	Control thrips with insecticides, as these insects transmit the virus.
Delphinium	Black leaf spot (bacteria)	Disease usually begins on lower foliage and spreads upward. Black spots develop on affected foliage. Bacteria can infect leaf, stem, and flower.	Remove and destroy infected plants. A protective fixed copper spray 2 Tbs/gal would be beneficial.
	Rhizoctonia crown rot (fungus) (fig. 7) (cover photo)	The fungus attacks the crown and as this occurs some of the flower stalks begin to wilt, turn brown, and die. Disease is favored by warm, moist weather conditions.	Remove and destroy all infected plants. Treat soil with Terraclor 75% WP ½ Tbs/gal at 1 pint/sq ft.
	Powdery mildew (fungus)	White powder fungus growth on leaves causes leaf distortion and leaf drop.	Spray with Benomyl 1½ tsp/gal or use Karathane 1½ tsp/gal or sulfur 1 Tbs/gal.
Geranium	Bacterial blight	Small, round water soaked, on leaves. Large, angular areas on leaves may wilt and turn necrotic due to stem rot. Upper roots and stems blacken and shrivel.	Use disease-free planting stock, avoid wetting foliage and provide good ventilation around plants. Destroy infected plants.
	Botrytis blight	Fungus can cause a blossom blight, leaf spot, and stem rot. Gray mold can develop on infected parts.	Remove dead tissue. Spray with benomyl 1½ tsp/gal, or Maneb 1 Tsp/gal.
	Root rot	Leaves and flowers fade in color and wilt. Roots are decayed and nonfunctional.	Plant in well-drained soils. Use sterilized soil for potting.

Table 2. Disease Control of Various Flowers

Plant	Disease	Symptoms	Control
Gladiolus	Fusarium dry rot (fungus) (fig. 8) (cover photo)	Note fungal lesions on corm. Stems may rot off below soil line and stems topple over.	Prior to planting, corms should be treated with Thiram 75% dust. Do not plant diseased corms. Drench corms in Mertect 160 (see label for instructions).
	Fusarium basal rot	Evidence of fungus on corm causes brown depressed areas.	Avoid corm injury while digging. Discard rotted or injured corms. Store in dry place at 35° to 40° F. Treat corms with Benomyl 6 Tbs/gal at 85° F for 20 minutes within 48 hr. after digging.
	Septoria hard rot (fungus)	Infected leaves develop circular or oval purplish spots. Black fungal structures can be seen within spots. On corm, water-soaked brown area can be seen when outside husks are removed.	Row treatment with Terraclor prior to planting is helpful. Practice crop rotation. Spray foliage with Zineb 1½ Tbs/gal.
	Penicillium rot (fungus)	Fungus causes sunken lesions on corm. Entire corm becomes soft and punky. Oftentimes a green mold can be seen on infected corms.	See Fusarium basal rot control measures.
	Scab (bacterium) (fig. 9)	Infected leaves develop small reddish-brown spots on leaf blade. Symptoms on corms include shallow circular brown lesions with raised tissue surrounding lesions.	Remove a husks and discard corms showing any spotting. Then dust with Thiram 75%. Practice a 3-year rotation. Plant in well-drained soils.
	Botrytis dry rot	Black fruiting bodies of fungus, as well as masses of gray spores, may occur on corm. Fungus can attack stem, leaves, and flower. Cool, moist weather conditions favor development.	Remove and destroy infected plant parts. Spray with Benomyl 1½ tsp/gal.
	Gladiolus break (virus)	Leaves are mottled with whitish streaks. Virus-infected plants show color break in flowers.	Remove and destroy infected plants. Control aphids.
Hollyhock	Rust (fungus) (fig. 10)	Small lesions develop on underside of leaf. Yellow spots with reddish centers appear on upper leaf surface.	Remove infected plant parts, as well as all leaves that have fallen to the ground. Spray with Zineb or Ferbam 2 Tbs/gal.
Iris	Bacterial leaf spot	Irregular spots develop on leaves which appear dark green. Entire plant may be infected during extended resting periods.	Remove and destroy infected plants. Spray with a fixed copper 1½ Tbs/gal. Avoid overwatering.
	Botrytis blossom blight (fungus)	Usually serious in rainy weather. Blossom and occasionally leaves covered with masses of gray spores.	Remove and destroy infected plants. Spray with Benomyl 1½ tsp/gal.
	Crown rot (fungus) (fig. 11)	The basal portion of flower stalks are invaded first. Tips of leaves turn brown and may collapse. Rhizomes become infected and dry rot develops. Small black fungal structures can be found on crown and rhizomes.	Avoid crowding plants. Remove infected plants and destroy. Plant disease-free plants. Drench soil with Terraclor 75% WP 1 Tbs/gal, 1 pint/sq ft.
	Black rot sclerotinia (fungus)	Often infected plant will not emerge. Those that do emerge turn yellow, wilt, and die. Bulbs and shoots below the ground are covered with white fungal growth, and small black fungal structures can be seen.	Plant disease-free bulbs. Practice a 3-year crop rotation. Drench soil with Terraclor 75% WP 1 Tbs/gal, 1 pint/sq ft.

Table 2. Disease Control of Various Flowers

Plant	Disease	Symptoms	Control
	Leaf spot (fungus) (fig. 12)	Small irregular dark leaves appear with gray centers and dark border. These spots run together and cover the upper leaf portion. Disease is usually more serious after plant has bloomed. Small black fungal structures can be seen in lesions.	Remove old leaves in fall and destroy them. Spray with Daconil 1½ Tbs/gal, or Folpet 1½ Tbs/gal, or Zineb 1½ Tbs/gal. A spreader should be used with all spray materials.
	Fusarium basal rot (fungus)	Fungus enters roots of bulbous iris, invading the scales of the bulb. Plants are stunted and weak. Root system is rotted.	See Fusarium basal rot control under gladiolus.
	Iris-mosaic (virus)	The virus causes a yellow streaking in the leaf and flower. Disease is more serious in bulbous iris. Plants are stunted, and some plant distortion occurs.	Remove and destroy all infected plants. Control aphids with insecticide.
Pansy	Anthracnose and leaf spot	Small spots develop on the leaves. Margins are marked with characteristic dark borders. Petals are also attacked.	Remove and destroy infected plants. Spray with Maneb 1½ Tbs/gal or Zineb 1½ Tbs/gal.
	Botrytis (fungus) (fig. 13)	Disease is favored by cool moist weather conditions. Affected plant parts are covered with masses of gray spores.	Avoid crowding plants; proper air circulation is very important. Spray with Benomyl 1½ tsp/gal.
Peony	Botrytis blight (fungus) (fig. 14)	Early in spring young stalks suddenly wilt and fall over. Flower buds turn brown and dry up. When weather conditions are favorable, masses of gray spores cover affected tissue.	Remove and destroy infected plant parts. Apply a fixed copper spray (2½ Tbs/gal) to ground shoots as they emerge. Repeat in a week. Remove all plant material in the fall and burn. Plant varieties more resistant to Botrytis. Spray with Benomyl 1½ tsp/gal, or Zineb 1½ Tbs/gal, or Folpet 1½ Tbs/gal.
	Leaf blotch (fungus)	Spots on infected leaves take on a glossy purple color. Corresponding spots on underside of leaf are dull brown. Disease development is favored by cool moist weather conditions.	Spray with Mancozeb 1½ Tbs/ gal. Remove and destroy old infected plant material at end of growing season.
	Leaf and Stem spots (fungi)	Fungi can affect stem, leaves, and flowers. Infection occurs on young succulent tissue. Spots appear as small elongated reddish areas which enlarge with red centers and gray borders. Similar symptoms are found on buds and leaf tissue.	Spray with Maneb 1½ Tbs/gal or Zineb 1½ Tbs/gal. Early spring spray is necessary. Remove all infected plant material.
	Phytophthora blight (fig. 15)	Fungus attacks leaves, stems, and buds. Infected plant parts turn black and somewhat leathery. Entire shoot may turn black and die. Fungus can infect crown, causing a root rot.	Remove and destroy infected plant parts. In the fall, cut off tops near ground line and destroy the debris. Drench crowns with Maneb 2 Tbs/gal or fixed copper 2 Tbs/gal. Spray foliage with Maneb 1 Tbs/gal.
	Verticillium wilt (fungus)	Oftentimes plant wilts during blooming stage. When basal shoots are removed and cut in cross section, a dark ring can be seen. Fungus plugs the vascular tissue causing plant to wilt.	Fungus overwinters in crown. Therefore infected plants must be removed and destroyed. Do not propagate from infected plants.
	Sclerotinia stem rot (fungus)	This pathogen is occasionally found on garden peony. Infected shoots wilt and die, and stems rot. When an infected stem is split, large black fruiting bodies of fungus can be seen.	Remove and destroy infected plant parts. Plant new plants in a different area. Remove old infected plants and destroy.

Table 2. Disease Control of Various Flowers

Plant	Disease	Symptoms	Control
Phlox	Leaf spot (fungus)	Many fungi cause leaf spot on phlox. Septoria is one of the most serious and most common. Symptoms appear as small circular black spots with light gray centers. Infected leaves are killed.	Remove and destroy infected plant material. Spray with Benomyl 1½ tsp/gal or Ferbam 2½ Tbs/gal.
	Powdery mildew (fungus) (fig. 16)	Grayish-white fungal growth covers the leaves. Disease usually develops late in the growing season.	Spray with Benomyl 1½ tsp/gal. Remove and destroy plant parts in the fall.
	Leaf blight (physiological)	Phenomenon is usually associated with older plants on shoots which give rise to new shoots in spring. Initial symptoms include leaf drop of lower foliage, which soon progresses upward until all leaves have fallen off.	It is thought that old stems cannot supply sufficient water to new shoots under moisture stress. Mulching and other systems which retain moisture can be placed around plant.
Rose	Black spot (fungus) (fig. 17)	Circular black spots appear on upper side. Spots are frequently surrounded by a halo. Infected leaves turn yellow and fall prematurely. Cane infection produces reddish-purple spots.	Remove and destroy infected leaves and canes. Use a preventive spray program. Spray with Benomyl 1½ tsp/gal, or Daconil 1½ Tbs/gal, or Folpet 1½ Tbs/gal, or Maneb 1½ Tbs/gal, or Zineb 1½ Tbs/gal.
	Botrytis blight (fungus)	A smooth, slightly sunken grayish-black lesion may develop just below flower head destroying the bud. The bud frequently hangs over at or near the lesion. Fungus may also infect stub ends of stems from which flowers have been cut. Masses of gray spores may be present on infected tissue.	Remove and destroy all infected plant parts. Spray with Benomyl 1½ tsp/gal, or Daconil 1½ Tbs/gal, or Zineb 1½ Tbs/gal.
	Brown canker (fungal)	First symptoms include small purple spots on stems, leaves, and petals. The cankers turn whitish-tan and later darken to a red color. Dark small fruiting structures of the fungus can be seen in the cankers.	Prune out infected canes and burn. Spray Benomyl 1½ tsp/gal, or Daconil 1½ Tbs/gal, or Folpet 1½ Tbs/gal, or Meneb 1½ Tbs/gal.
	Crown gall (bacterial)	Disease is occasionally found on garden roses. Gall formations appear at the crown or at grafting point. Galls may be found on upper portions of stems.	Remove all gall infected tissue and destroy. Avoid planting in infested soil. Spray plants with 50 ppm Streptomycin.
	Powdery mildew (fungus) (fig. 18)	Fungus produces white growth on leaves. Infected leaves are distorted and stunted.	Spray with fungicides listed under black spot.
	Common stem canker (fungus)	Oftentimes fungus can be found on canes that were pruned the previous year. Young cankers are pale yellow or sometimes reddish. Older cankers crack, are brown, and are depressed into the cane. Small dark fungal fruiting bodies can be seen in association with cankers.	Prune out all infected canes and destroy. Remove all debris from around base of plant. Spray with Benomyl 1½ tsp/gal, Daconil 1½ Tbs/gal, or Maneb 1½ Tbs/gal.
	Rose graft canker (fungus)	Small pale yellow spots are initial symptoms. Older cankers turn reddish and increase in size. Cankers are usually located near the ground. Infected wood dies; bark cracks and splits. Small fungal fruiting bodies can be found in canker area. Fungus enters canes through wounds, such as grafting wounds.	Use Rosa manetti understock and clean scions. Cut back to nodes when pruning; do not leave stubs. Sprays include those listed under brown rot control.

Table 2. Disease Control of Various Flowers

Plant	Disease	Symptoms	Control
	Rust (fungus) (fig. 19)	Bright red-to-orange spots appear on leaves and stems.	Remove and destroy infected canes. Remove old plant debris from around base of plant. Spray with Zineb 1½ Tbs/gal or mixture of Ferbam 2 Tbs and sulfur 1Tbs/gal.
Snapdragon	Leaf blight and leaf spots	Look for spotting on foliage and flowers. Oftentimes small black fungal fruiting bodies can be seen on infected leaves. Growth masses of gray spores indicate Botrytis.	There are many fungi that attack the foliage of snaps. These fungi can be controlled by spraying with Maneb, Mancozeb, or Zineb (1½ Tbs/gal).
	Powdery mildew (fungus)	White fungal growth appears on leaves. Leaf distortion and stunting may occur.	Spray with Benomyl 1½ tsp/gal or Karathane 1½ tsp/gal. Use a spreader. Avoid crowding plants.
	Rust (fungus)	Symptoms include reddish spots on the underside of leaf. Severely infected plants wilt and die.	Plant rust-resistant varieties. Avoid crowding plants. Spray with Nameb 1½ Tbs/gal or sulfur 1½ Tbs/gal. Dust may be used.
	Stem rot (fungus)	Water-soaked areas appear on the stem near soil line. Stems soon topple over and are sometimes covered with a white cottony fungal growth. Flower buds wilt. When stem is broken open, black fungal structures are found within.	Treat soil with Terraclor. See iris.
Sweet Pea	Anthrachnose	White-to-tan area can be seen on leaves. Leaves often fall off at blooming time. The growing tips may shrivel and die. Entire flower stalk may be killed.	Since the fungus is seed-borne, care must be taken to purchase from a reputable company. Spray foliage with Ferbam 2½ Tbs/gal.
	Black root rot (fungus)	Roots are rotted and lower stem is black. Top portion of plant is yellow and wilted.	Treat the soil with Captan 1 Tbs/gal. Mix into soil prior to planting.
	Leaf spots (fungal)	Initial symptoms include pale yellow spots which turn brown. Size and shape of spot on leaf tissue may vary, depending on the pathogen involved.	Spray with Benomyl 1½ tsp/gal or Maneb 1½ tsp/gal.
	Powdery mildew (fungus)	White powdery growth appears on the leaves. Leaves may be distorted and stunted.	Spray with Benomyl 1½ tsp/gal or sulfur (wettable) 1½ Tbs/gal.
	Pea mosaic (virus)	Young plants are stunted and leaves curled. Leaves yellow and become mottled. Infected plants produce few flowers. Blooms have discolored streaks.	Remove and destroy diseased plants. Control aphids. Avoid planting near other legume-type plants.
Tulip	Botrytis blight (fungus) (fig. 20)	On the bulbs black fungal structures can be seen in addition to brown lesions. Symptoms on leaf include water-soaked spots and yellowing. These enlarge, turn gray, and are covered with masses of gray spores. Blossoms can also be attacked; flecks appear on flowers.	Remove outer husks. Discard any diseased bulbs. Remove all plant debris after blooming. If bulbs are to remain in soil, cut yellowed tops below ground and burn them. Drench soil prior to emergence with Terraclor 1 Tbs/gal or Benomyl 1½ tsp/gal. Spray foliage Ferbam 2½ Tbs/gal or Zineb 1½ Tbs/gal.

Table 2. Disease Control of Various Flowers

Plant	Disease	Symptoms	Control
	Basal rot (fungus)	Infected bulbs are dull white and base of bulbs is sunken. Disease occurs only in certain areas in the U.S.	Carefully look bulbs over before purchase.
	Gray bulb rot	Fungus is soil-borne; it enters roots and moves up to the bulb and leaf base. The flowers topple over. Often the bulbs become covered with brownish fungus which forms small black structures on rotting bulbs.	Remove and destroy infected plants. Practice a 4-year rotation. Select clean bulbs. Treat soil with Terraclor 75% WP. See iris crown rot control.
	Stem rot (fungus)	Infected stems turn brown to black near the soil line. Affected tissue is water soaked. Flowers topple over as stalks shrivel.	Avoid crowding plants, and plant only in well-drained soils.
Zinnia	Alternaria blight (fungus)	Symptoms include small reddish-brown spots with gray centers. Dark brown cankers occur on the stem. The fungus attacks the flowers, causing a stunting or complete blight.	The fungus can be carried on the seed; therefore, treat seed with Thiram ½ tsp/pound of seed. Spray foliage with Maneb 1½ Tbs/gal or Zineb 1½ Tbs/gal. Begin spraying when buds develop.
	Powdery mildew (fig. 21)	White fungus growth appears on the leaves. Leaf stunting and distortion may occur.	Spray with Karathane 1½ tsp/gal or Benomyl 1½ tsp/gal. Avoid crowding plants.
	Root and stem rots	This disease is caused by several soil-borne fungi. Infected plants are stunted and a pale yellow color. Plants wilt because of rotted roots.	Plant only on well-drained soils. Avoid crowding plants.
	Viruses (fig. 22)	Several viruses can attack zinnia. Symptoms include stunting of plant, leaf mottling, and leaf distortion.	Control aphids. Remove and destroy infected plants.

Table 3. Flower Seed and Planting Stock Treatment

Crop	Fungicides and Methods of Treatment	Diseases Controlled
Flower seeds	Dust with thiram ½ tsp/lb of seed.	Seed decay; damping-off
Flower seedlings	Drench at rate of 1 pint per sq ft with captan 50% WP or ferbam 76% WP 2½ Tbs/gal.	Post-emergence damping-off
Chrysanthemum	Spot drench with Terraclor 75% WP 1 Tbs plus captan 50% WP ¾ Tbs/gal (1 pint per sq ft).	Root and basal stem rot of cuttings
Delphinium or Larkspur	Dust with thiram ½ tsp/lb of seed.	Seed decay; damping-off
Gladiolus	Dust with thiram dust or soak in thiram (1 lb/gal).	Scab; bacterial blight, Fusarium basal rot
Iris	Drench soil with Terraclor 75% WP 1 Tbs/gal (1 pint per sq ft).	Crown rot
Peony	Drench crown and soil with ferbam or fixed copper 2½ Tbs/gal. Drench crown and soil with maneb, mancozeb, or fixed copper (2 Tbs/gal).	Botrytis blight; Phytophthora blight
Snapdragon	Drench soil with Terraclor 75% WP 1 Tbs plus captan ¾ Tbs or ferbam 1 Tbs/gal.	Damping-off; Rhizoctonia basal stem rot
Sweetpea	Dust seed with thiram ½ tsp/lb.	Anthracoze; seed decay; damping-off
Zinnia	Dust seed with thiram ½ tsp/lb. Hot water treat 125° F for 30 minutes, dry, and dust with thiram 1 tsp/lb. Do not hot-water treat seed over 1 year old as injury may occur.	Seed decay; damping-off; Alternaria blight

SPECIAL NOTE: A statewide Poison Information Center operates at the Hennepin County Medical Center, 619 S. 5th Street, Minneapolis. Information about pesticides and common household poisons, antidotes, and treatments is available 24 hours a day by calling the following telephone number:
(612) 347-3141

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