

FARMERS'
BULLETIN
NO. 2140

STRAWBERRY DISEASES



U. S. Department of Agriculture

STRAWBERRY DISEASES

By JOHN R. MCGREW, *pathologist, Crops Research Division,
Agricultural Research Division*

Strawberries are attacked by many diseases, which vary widely in their destructiveness and distribution. The ideal way to cope with these diseases is to hold them in check through preventive measures.

In most localities losses may be reduced by (1) using adapted cultural practices, (2) selecting adapted varieties, and (3) planting disease-free stock.

Cultural practices.—Use the cultural practices that are adapted to your locality. These will enable you to grow vigorous plants. Two cultural practices recommended in most localities are crop rotation and frequent renewal of plantings and plant stocks.

Varieties.—Select varieties that do well in your locality. If a particular disease is a problem, choose, if possible, varieties resistant to it.

Disease-free stock.—Use disease-free stock for planting new fields. Only a few of the major diseases are now common throughout the country. But most of them can be introduced into new areas by planting infected stock.

When you buy planting stock it is best to patronize nurseries that sell plants certified to be disease free by the State plant-inspection service.

If you use runner plants from old fields to set new fields, do not use any from plants that you know or suspect are diseased.

DISEASES OF THE ENTIRE PLANT

Diseases of the entire plant include all the virus diseases of strawberries and leaf variegation (also called spring yellows).

Virus Diseases

Viruses are disease-causing agents so small they cannot be seen, even through a microscope. Several viruses infect strawberries. Most strawberry virus dis-

eases are a combination of two or more of these viruses (a virus complex).

Though one virus or even certain combinations of viruses may not cause the plant to show obvious symptoms or noticeable loss of vigor, their presence in the plant does weaken it. Loss of vigor may show up in the weakened plant if growing conditions are unfavorable. Obvious symp-

and have very few runners. Leaves usually cup upwards; they have dull green centers and yellow edges.

Multiplier.—Plants are spindly and have many crowns, sometimes as many as a hundred. Leafstalks are thin and somewhat shorter than normal. Leaves are from one-third to one-half normal size. There are only a few very short runners or none.

Leaf roll.—Leaves tend to cup downward and often are rolled or twisted into a tube.

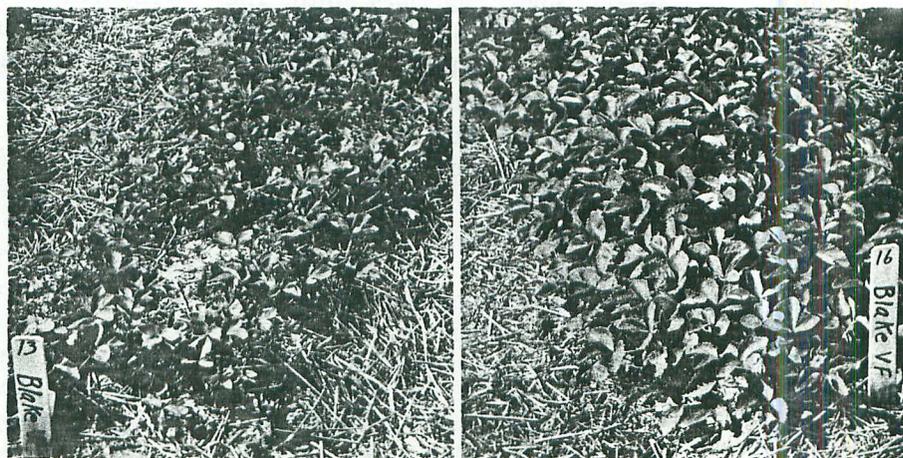
Aster yellows.—Early symptoms are yellowing, dwarfing, and cupping of young leaves. Later, most plants showing early symptoms die suddenly, as do all attached runner plants. Sometimes abnormal green, leafy flowers are produced before the plant dies. When the disease appears in a field, usually only a few scattered plants are affected. Sometimes,

however, over half the plants in a field may be affected; the rate of spread varies greatly from year to year.

Damage.—All virus diseases weaken plants, cut runner formation, and hold down berry yields.

Crinkle and yellows do the most damage. Crinkle often reduces yields by 50 percent or more. Yellows reduces both quantity and quality of yield and shortens the life of the planting. Losses from both diseases are greatest in strawberries of the Marshall variety, which is very sensitive to both diseases. Shasta, Lassen, and Northwest varieties are rather tolerant to both diseases.

Virus diseases that do not produce obvious symptoms may reduce yields as much as 50 percent, judging by tests conducted on experimental planting stock. Strawberries of all varieties appear to be weakened by these diseases,



N-27674, N-27672

Virus-infected and virus-free Blakemore plants grown under the same experimental conditions. Infected plants at left have no obvious symptoms other than poor vigor. Poor vigor may also result from a number of unfavorable growing conditions.

PRECAUTIONS

Insecticides are poisonous to man and animals. Use them only when needed and handle them with care. Follow the directions and heed all precautions on the labels.

Keep insecticides in closed, well-labeled containers in a dry place. Store them where they will not contaminate food or feed, and where children and animals cannot reach them.

When handling an insecticide, wear clean, dry clothing.

Avoid repeated or prolonged contact of insecticides with your skin.

Wear protective clothing and equipment if specified on the container label. Avoid prolonged inhalation of insecticide dusts or mists.

Avoid spilling insecticide concentrate on your skin, and keep it out of your eyes, nose, and mouth. If you spill any on your skin, wash it off immediately with soap and water. If you spill it on your clothing, launder the clothing before wearing it again.

After handling an insecticide, do not eat, drink, or smoke until you have washed your hands and face. Wash your hands and face and any other exposed skin immediately after applying insecticide. If you become ill while

working with an insecticide, get medical attention immediately.

To protect water resources, fish, and wildlife, do not contaminate lakes, streams, or ponds with insecticide. Do not clean spraying equipment or dump excess spray material near such water.

To protect honey bees and other pollinating insects that are necessary in the production of many crops, apply insecticide, when possible, during hours when the insects are not visiting the plants.

Avoid drift of insecticide to nearby bee yards, crops, or livestock.

Dispose of empty insecticide containers at a sanitary land-fill dump, or bury them at least 18 inches deep in a level, isolated place where they will not contaminate water supplies. Wrap small containers in heavy layers of newspapers and place them in the trash can.

Demeton, parathion, and tepp are extremely dangerous. They should be applied only by a person thoroughly familiar with their hazards who will assume full responsibility for safe use and comply with all the precautions on the labels.

Do not apply demeton within 21 days before a harvest, parathion within 14 days, diazinon within 5 days, or malathion or tepp within 3 days.

known. The most common damage by nematodes is caused by two types that enter the roots to feed.

Red Stele

Red stele,³ the most serious fungus disease of strawberries in the United States, attacks plants during the late winter and spring. The fungus that causes the disease attacks no other crop except loganberries. The fungus does not persist in soils in the South or in well-drained soils in any area; it persists in all other soils.

Red stele is spread from one area to another principally by distribution of diseased plants. It is spread within an area by water that moves within or over the soil and by soil carried on farm implements.

Distribution.—Red stele is common throughout the northern two-thirds of the country. It has also been found as far south as Georgia and Arkansas.

Symptoms and damage.—The symptom that positively identifies this disease is found in the center (or stele) of the root. In a normal root both the center and the part surrounding the center are yellowish white. In a plant with red stele the center is a distinctive brownish red, which contrasts with the normal yellowish white of the part around it. The red color may extend the length of the root or it may show only a short distance above the dead tip. It does not extend to the

³ Caused by *Phytophthora fragariae* Hickman.

crown of the plant; any discoloration there has some other cause.

The red center is best seen during the spring, up to the time of fruiting. Later in the season it may disappear as the rotted roots are replaced with new ones.

Other symptoms that should make you suspect red stele are: Poor growth and frequent wilting of plants, especially those in low, wet areas of the field; younger leaves that have a bluish-green cast; older leaves that turn yellow or red. When dug, some of the roots of diseased plants have a rattail appearance—unbranched with black tips or black patches.

Plants infected with red stele are stunted. They wilt in dry weather. Often they die just before the fruit starts to ripen. In diseased plants that do not die symptoms disappear during warm summer weather. These plants may recover and produce a few worthless fruits, but symptoms usually recur in the late fall or the following spring.

Red stele may infect only a few plants in low areas of the field. Or it may be distributed throughout a field or strawberry-growing region. It is most destructive in heavy or poorly drained soils that are saturated with water in cool weather when the fungus is active; the swimming spores move through this free water to attack the plants.

What to do if the disease occurs.—At present there are no chemical or cultural treatments that will assure a normal crop in an infected planting. The only

Molalla, and Siletz carry resistance to several races that occur in the West.

Prevention.—Avoid, if possible, setting infected planting stock. Look roots over carefully to see if any have the rattail appearance that may indicate red stele. Cut any suspicious roots to see if there are typical red stele symptoms. State plant-inspection services cannot identify every shipment that contains red stele-infected plants because the distinctive red center that positively identifies this disease may not be present at the time of inspection, or only a few plants from a nursery field may be diseased.

Avoid planting any but resistant varieties in infested land.

Verticillium Wilt

The fungus ⁴ that causes this disease lives from year to year in the soil. Besides strawberries, many other common crops and several kinds of weeds are also hosts of this fungus.

Distribution.—Verticillium wilt occurs throughout the United States.

Symptoms and damage.—The fungus is most active during cool weather. In new plantings symptoms appear about the time runners begin to form. In established plantings symptoms appear about the time fruit begins to ripen.

Outer leaves wilt and dry at the margins and between the

veins; they become dark brown. Few, if any, new leaves develop. New roots that grow from the crown often are very short and have blackened tips. Plants appear to be dry and flattened. Black sunburn lesions may appear on leafstalks and runners. Severely affected plants collapse, sometimes abruptly. Less severely affected plants are unproductive. In the East less severely affected plants usually recover and produce normally the next year. In the West affected plants usually do not recover.

The disease will often appear in mother plants but not in rooted daughter plants. Thus it is more obvious when strawberries are grown in hills than when they are grown in matted rows.

Some of the most susceptible varieties are Dixieland, Earli-dawn, Jerseybelle, Klondike, Lassen, Northwest, Shasta, and Vesper. Varieties that have some resistance are Blakemore, Catskill, Marshall, Robinson, Siletz, Sunrise, Surecrop, and Vermilion.

Prevention.—In the East allow 2 years between tomatoes, or peppers, or potatoes and strawberries.

In the West do not grow susceptible strawberry varieties on land that has a history of having been planted to tomatoes, peppers, potatoes, cotton, okra, melons, eggplant, mint, apricot, almond, pecan, cherry, avocado, roses, or cane fruit. The verticillium wilt fungus has been known to persist in the soil in the Pacific States for more than 10 years.

⁴ *Verticillium albo-atrum* R. and B.

Nematodes that enter the roots to feed can stay alive in the roots when plants are dug, stored, and shipped—even if they are shipped barerooted. Nematodes that feed on the surface of the roots usually are dislodged when the plants are dug and the soil removed from the roots.

Most root nematodes are more destructive in sandy soils than in clay soils.

Northern root-knot nematode

The northern root-knot nematode⁵ is the only species of root-knot nematodes that attacks strawberry plants. It also attacks many other plants and common weeds; it does not attack most grains and grasses.

Distribution.—Much cropland in the northern two-thirds of the country is infested with the northern root-knot nematode. It is found in the South only where it has been introduced on strawberry plants or where peanuts have been grown extensively.

Symptoms and damage.—These nematodes form swellings (or galls) on the roots. Swellings range in size from minute to about $\frac{1}{4}$ inch in diameter, averaging $\frac{1}{8}$ inch in diameter. Usually there are several short branch roots just above the swelling.

A severe infection has the same effect on the plant as removing most of the roots: Plants are weakened, are more subject to

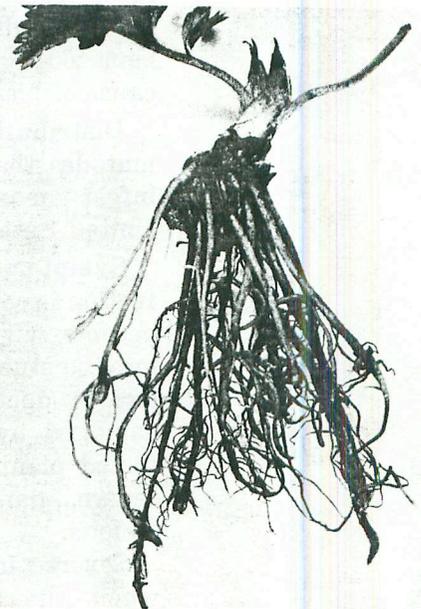
⁵ *Meloidogyne hapla* Chitwood.

drought injury, and make fewer runner plants; therefore they produce less fruit. Damage usually becomes more severe as the nematode population on the plant increases during the second and later fruiting years.

What to do if plantings are infected.—Practice very shallow cultivation to keep roots from further damage. Eliminate weeds. Maintain high soil fertility. Irrigate during dry periods.

Prevention.—Plant only stocks that are free of root knot. This is important because infested strawberry plants may carry nematodes into land where they do not now occur.

Many nurseries now treat their plants to free them of root knot. Several State quarantine services



BN-6985

Roots infected with the northern root-knot nematode. Note swellings, and branch roots above each swelling.

SOIL FUMIGATION

Before Planting

Nematocides will, if applied to the soil properly, kill a high percentage of most nematodes that attack strawberries. Most fumigants must be applied at least 3 weeks before planting time. Because the toxic gas they give off will kill plants as well as nematodes, this gas must be out of the soil before the strawberries are set.

Usually a grower will prefer to use a soil fumigant first on only a part of the land to see if increased yields justify the expense. If other conditions are favorable, yields will increase markedly the first year. Although the few nematodes that remain after fumigation can increase in number rapidly, the beneficial effect of fumigation may last throughout the life of the strawberry planting.

Before applying soil fumigants to a field, consult your county agent or State agricultural experiment station for suggestions concerning materials to use. If you wish a copy of Agriculture Handbook 286, "Chemical Control of Plant-Parasitic Nematodes," send a post card request to the Office of Information, U.S. Department of Agriculture, Washington, D.C. 20250.

In general, successful fumigation before planting consists of

careful preparation of the soil and application of a correct amount of fumigant to the proper soil depth with special equipment. The fumigant should be applied only when soil temperature measured at a depth of 6 inches is between 50° and 80° F. Soil should be neither waterlogged nor dry at the time of application. Plants should not be set sooner than recommendations of the manufacturer as stated on the label.

In Established Plantings

The material dibromo chloropropane has been used with good results to reduce root knot and sting nematodes on established strawberry plantings. It is applied as a side dressing at rates recommended by the manufacturer.

Precautions

Soil fumigants are poisonous. Handle them in accordance with the manufacturer's directions on the package. Do not breathe the fumes.

Never risk getting the liquid into the eyes or mouth. Do not allow the liquid to stay on the skin; wash it off promptly with soap and water. If liquid is spilled on shoes, gloves, or other clothing remove the clothing without delay, and do not wear again until thoroughly aired or cleaned.

comes tan or gray, then almost white; the border remains purple. On the underside of the leaves the spots show as indistinct tan or bluish areas.

If other parts of the plant are attacked they are marked by spots like those on the upper side of the leaves.

In *leaf scorch*, small dark-purple spots up to one-fourth of an inch in diameter appear on the upper side of the leaves. These spots never have light centers as do those of leaf spot and they have a more irregular outline. If spots become so numerous that they cover most of the leaf, the leaf dries up and looks scorched.

Similar spots may appear on other affected parts of the plants.

Leaf spot damage.—A severe attack of leaf spot kills so many leaves that the whole plant is weakened or killed.

Whether a trace of leaf spot in a field is likely to cause much damage if left uncontrolled depends on the variety being grown and on weather conditions at the time new leaves are developing.

Several strains of the leaf spot fungus are known, which affect varieties differently. In general, the manner in which varieties react is as follows:

Fairland, Florida Ninety, Klondike, Marshall, Sparkle, Sunrise, and Vesper varieties are very susceptible to leaf spot. Dixieland, Dunlap, Fairpeake, Jerseybelle, Midway, Pocahontas, and Vermilion are moderately susceptible. Blakemore, Catskill, Earlidawn, Robinson, and Surecrop are only

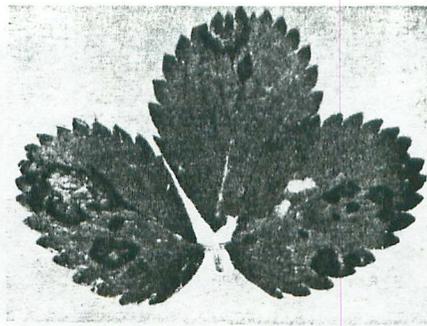
slightly susceptible. Albritton, Dorsett, Earlibelle, Fairfax, Howard 17 (Premier), Klommore, Midland, Rockhill are resistant.

If there are frequent rains during early spring, a few leaf-spotted plants can start an epidemic. Clusters of spores emerge from the white centers of the spots. Rain scatters them to nearby leaves; there they germinate and start new spots. A spring application of nitrogenous fertilizer can increase the amount of the disease because it increases the amount of young leaves at the time when leaf spot is most likely to occur.

Leaf scorch damage.—A severe leaf scorch attack may kill so many leaves that the whole plant is weakened or killed. Leaf scorch also often does considerable damage to caps, leafstalks, runners, and fruitstalks as well as to the leaves. Scorch spots may girdle the fruitstalks, causing the death of flowers and young fruit.

Whether leaf scorch is likely to cause much damage in a field if left uncontrolled when found on only a few plants depends on the variety and on weather conditions during early spring and fall. In hot dry summer months there is little spread of leaf scorch.

Varieties that are susceptible to leaf scorch are Dixieland, Florida Ninety, Jerseybelle, Klondike, Midway, Pocahontas, and Vesper. Moderately susceptible varieties include Sparkle, and Tennessee Beauty. Resistant varieties are



68700

Leaf blight as it appears on upper side of leaves. Spots are red to brown, with a purplish border.

than 1 inch across, and are oval or triangular in shape.

Leaf blight is found most often on older plants after harvest. It seldom damages these plants seriously unless they are less vigorous than normal. It seldom damages young runner plants.

Among varieties most susceptible to this disease are Catskill, Dunlap, and Robinson. Earldawn, Empire, and Howard 17 (Premier) seem to have some resistance.

What to do if disease occurs.—The fungicide sprays recommended for prevention of leaf spot and leaf scorch can be used to control leaf blight.

Prevention.—Leaf blight can be reduced by a single application of phenyl mercury acetate spray in the spring. Spray after mulch has been removed but before there is any extensive new growth; this spray will injure actively growing foliage. A fall application before mulch is put on will reduce leaf blight, but it is usually not so effective as a spring application. Apply at the rate

recommended by the manufacturer. Observe limitations on use of this fungicide given on page 27.

This spray will also control stem end rot of fruit (p. 25).

Powdery Mildew

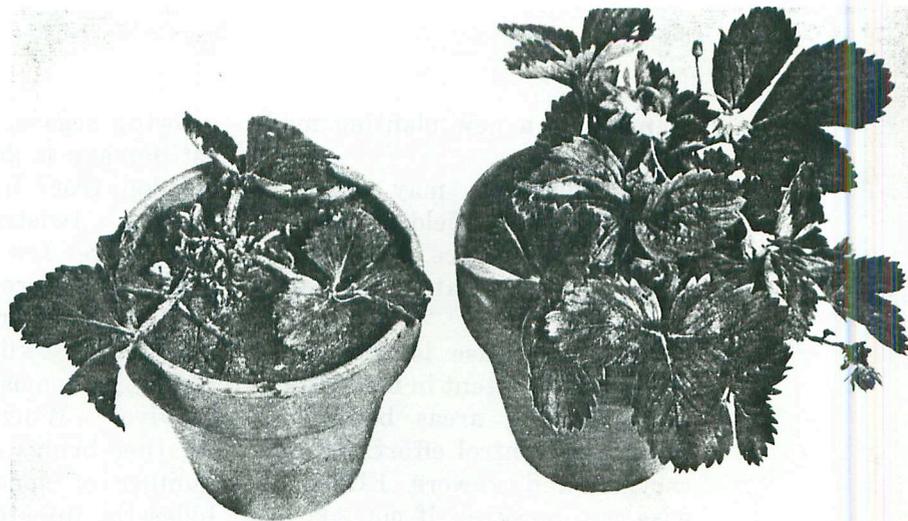
Powdery mildew¹¹ occasionally becomes severe in the Pacific Northwest. It causes damage in other parts of the United States only when there are extended periods of cool weather during the growing season.

Among varieties most susceptible to this disease are Armore, Earlibelle, Jerseybelle, Lassen, Midland, Northwest, Redglow, Shasta, Stelemaster, and Tennessee Beauty. Some of the most resistant are Catskill, Dunlap, Empire, Klondike, Siletz, Sparkle, and Sunrise.

Symptoms.—The most conspicuous symptom of mildew is an upward rolling of the edges of the leaves. Also, a thin white growth of cobweblike mold appears on the lower surface of the leaves and on stems and fruit. If attack is severe, leaves may show purple blotches or they may be killed.

What to do if disease occurs.—Sulfur dust or Karathane can be used to control powdery mildew. Both of these materials, however, can severely injure leaves and flowerstalks if the weather turns hot. Both sulfur and Karathane may be applied up to the time of

¹¹ Caused by *Sphaerotheca macularis* (Wallr. ex Fries) W. B. Cooke.



DN-1588

Bud rot. Plant at left infected, plant at right normal. Both plants are the same age.

is left of the original buds; these may also be killed, or they may survive as weak, spindly growths. Some plants are killed; usually, however, infected plants recover but produce no fruit that year.

Bud rot can be distinguished from spring dwarf in two ways. Plants infected with bud rot are not grouped together in a field; those with spring dwarf are. Bud rot-infected plants show rotting of leafstalks and dead or decaying bud tissues in the crown; decayed tissues are less likely to occur in plants with spring dwarf.

Nematode Infection

Three species of nematodes attack strawberry plants above-ground. One causes spring dwarf, one causes summer dwarf, and one damages leafstalks, fruitstalks, and new leaves.

Spring dwarf, summer dwarf

Spring dwarf¹³ and summer dwarf¹⁴ are caused by closely related nematode species that live inside leafbuds. The nematodes feed by sucking the sap from the tightly folded leaves within the bud. The injury to the leaves results in dwarfing and other malformations that show after the leaves unfold.

Both diseases are most commonly spread through setting of infected plants. The spring dwarf nematode does not persist in the soil long enough to spread the disease from an old planting to a new planting. The summer dwarf nematode persists long enough to spread the disease from an old

¹³ Caused by *Aphelenchoides fragariae* (Ritzema-Bos) Christie.

¹⁴ Caused by *A. besseyi* Christie.

Prevention.—Plant only stock that is free of dwarf nematodes. If you obtain plants from your own field or from a neighbor, avoid those from fields that you know or suspect are infected.

Most nurseries, because of careful selection of stock, are free from these and other foliar nematodes. In most States, plants with any foliar nematodes cannot be certified by plant inspectors.

Bulb and stem nematode

The bulb and stem nematode,¹⁵ a serious pest of clovers, sometimes attacks strawberries. It has appeared most frequently in the Pacific Northwest—usually in

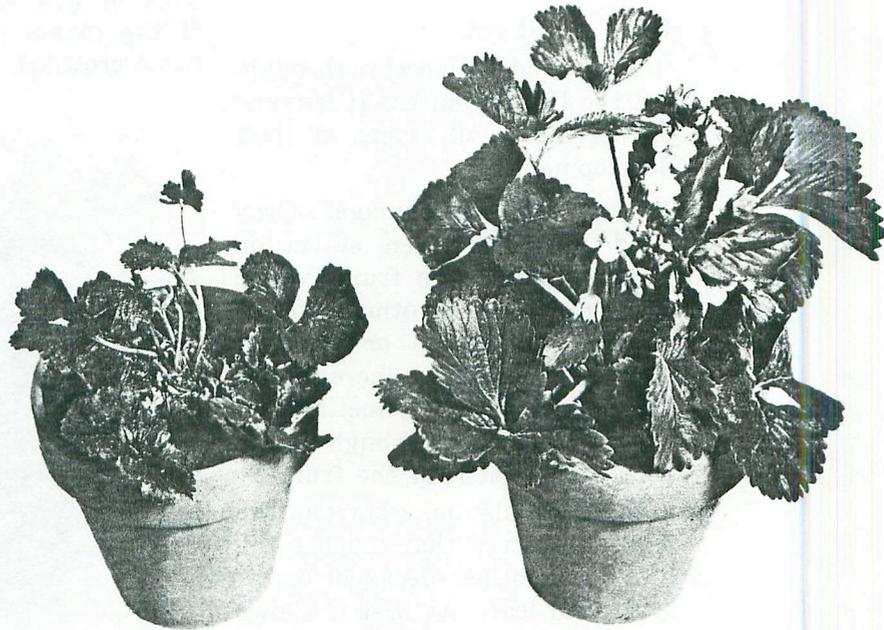
¹⁵ *Ditylenchus dipsaci* Kuhn.

fields in which the pest has attacked previous crops or near infected plantings of clover.

Symptoms are short, abnormally thickened leafstalks and fruitstalks, and distorted leaves. Plants may be severely stunted and unproductive. Symptoms usually appear only on parts of the plant that develop early in the season. The disease is most severe during a cool, wet spring.

If only a few plants in a field are infected, remove and destroy them.

To prevent infection with this nematode, do not plant strawberries near or in soils that have a history of this nematode on other crops. Do not use plants from diseased fields in new plantings.



Spring dwarf. Plant at left infected, plant at right normal. Both plants are the same age.

DN-1589

Apply any fertilizer in fall or summer rather than in spring. Fertilizer applied in the spring produces thick foliage; shading by thick foliage prevents rapid drying of berries after rains and heavy dews; this helps form suitable conditions for development of rots.

Mulching (with straw, pine needles, or other materials) when practical, will also help reduce the damage from fruit rot; the fungi that cause fruit rots live in or on the soil and in infected leaves and plant debris. Whether plants are mulched or not, cultivate as little as possible from bloom until after harvest.

Another control measure—spraying or dusting with fungicides—probably will reduce the amount of rot damage except when conditions are extremely favorable to the growth of rot fungi. This control measure often costs more than it is worth, however.

Spray with captan, ferbam, zineb, or dyrene as soon as blossom buds are visible in the spring. Spray every 2 weeks until the berries are one-third grown. After this time, spray only if rot is present or if extensive cool or rainy periods are predicted. Observe limitations on use of these fungicides given on page 27.

Tan rot

Tan rot¹⁷ occurs in the South-

¹⁷ Caused by *Pezizella lythri* (Desm.) Shear and Dodge.

ern States. It attacks both green and ripe berries.

Symptoms and damage.—Tan rot forms slightly sunken, tan-colored areas on the berry surface; these usually develop on the sides of the berries. As the rot extends into the berry, the rotted part widens and forms a cone. This can easily be removed in one piece with the point of a knife or pencil.

What to do if disease occurs.—Same as for gray mold rot.

Prevention.—Same as for gray mold rot.

Hard rot

Hard rot¹⁸ occurs throughout the United States. It has been most serious in central Florida. It attacks only ripe berries.

Symptoms and damage.—Hard rot usually attacks only berries that touch the ground as they grow. Affected berries generally are one sided and show a hard brown area on the side that touched the ground. There is a distinct line between the rot and the rest of the berry. The rest of the berry remains unchanged in appearance and in taste.

What to do if disease occurs.—Same as for gray mold rot.

Prevention.—Same as for gray mold rot.

Leather rot

Leather rot¹⁹ occurs in Alabama, Louisiana, Mississippi, Ar-

¹⁸ Caused by *Rhizoctonia* sp.

¹⁹ Caused by *Phytophthora cactorum* (Leb. and Cohn) Schroet.

Brown Caps

When caps are killed and dried out they turn an unattractive brown. Although this cap discoloration does not affect the taste of the berry, berries with brown caps bring a lower price than those with bright green caps.

The most common causes of brown caps are the fungi that cause the various fruit rots.

A combination of high temperature and low humidity, especially when accompanied by wind, can kill berry caps. Strawberries of Klondike, Missionary, and Blake-more varieties have weak caps that are easily killed by such weather conditions.

Prevention.—Spraying or dusting with the fungicides recommended for the prevention of gray mold rot will often reduce the amount of brown caps.

ACCEPTABLE RESIDUE TOLERANCES FOR FUNGICIDES

For certain pesticide uses the Food and Drug Administration of the U.S. Department of Health, Education, and Welfare has established acceptable residue tolerances—that is, the maximum amount of a certain pesticide that may be left in or on a certain food in its raw or natural state.

You can be reasonably sure that the residue levels of the fungicides recommended in this publication will not exceed the tolerances set for them on strawberries if you use the fungicide according to the manufacturer's directions. Read the label carefully; use no more of the fungicide than is recommended; follow exactly the directions for timing of applications;

Precautions.—Some chemicals used as fungicides may be injurious to man or animals. Observe carefully the manufacturer's recommendations for safe handling, given on the container.

observe any other restrictions listed.

The table below shows the maximum dosage of fungicides that may be used on strawberries (as of 1965) and the various restrictions on application. Dosages lower than the maximum (as given on the label) usually are sufficient to control the diseases for which the fungicides are recommended.

INDEX TO DISEASES

	Page
Aster yellows virus	4
Black root-rot	11
Black-seed	25
Brown caps	26
Bud rot	19
Bulb and stem nematode	22
Crinkle virus	3
Fruit rots	23-26
Gray mold rot	23
Hard rot	24
Leaf blight	17
Leaf roll virus	4
Leaf scorch	15
Leaf spot	15
Leaf variegation (spring yellows)	7
Leather rot	24
Multiplier virus	4
Nematode infection	11-15, 20-22
Northern root-knot nematode	12
Powdery mildew	18
Red stele	8
Root-lesion nematode	13
Spring dwarf	20
Spring yellows. (See Leaf variegation.)	
Stem end rot	25
Sting nematode	13
Summer dwarf	20
Tan rot	24
Verticillium wilt	10
Virus diseases	2-7
Yellows virus	3

☆ U.S. GOVERNMENT PRINTING OFFICE: 1966—O 210-485



Use Pesticides Safely
FOLLOW THE LABEL

Washington, D.C.

Revised July 1966

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 Price 15 cents