Foreword

In 1940 the cash farm income from the 13,400 acres of strawberries grown in Oregon was $2,152,000. During the war years, the acreage declined to a low of 5,300 acres in 1944, but because of increased prices the farm income from them was $2,977,000. Since then, the acreage has increased rapidly until in 1950 there were 14,000 acres and a cash farm value of $10,206,000.

Diseases and insect pests have greatly reduced income and yields in recent years. To obtain paying yields now and in the future, it is necessary to maintain a high degree of control of the diseases and insect pests of this important crop.

This bulletin presents descriptions of and suggestions for control of the various insect pests and diseases of strawberries occurring in Oregon.

F. E. Price
Dean and Director
Introduction

Production of strawberries for market has become an important industry in Oregon. An average of 13,800 acres was devoted to strawberries during the 1947-1951 period and the average value of the crop to growers was $8,146,600 for those same years.

Consequently, production problems, especially those connected with pests and diseases, have become a matter of serious concern for many growers. This is especially true because high yields and fancy packs are necessary to compete with other strawberry producing areas in the East and Middle West. Unit cost of production has become an essential factor.

This bulletin is a general revision of the previous Station Bulletin 419 and is published to assist commercial growers and gardeners in Oregon to maintain high quality and large yields. It presents a discussion of the more common insect pests and diseases of strawberries in Oregon.

Insect Pests of Strawberries

Root Weevils

Brachyrhinus spp.; Dyslobus spp.

Root weevils are one of the most serious pests of strawberries in Oregon. One or more of the following species are found in all of the strawberry-growing areas of the state. They have a very wide range of cultivated and wild host plants.

The Brachyrhinus, or black weevil group, consists of three species: the strawberry root weevil (B. ovatus), the rough strawberry
root weevil (*B. rugosostriatus*), and the black vine weevil (*B. sulphuratus*).

The Dyslobus group, or gray weevils, consists of the following species: the decorated strawberry root weevil (*D. decoratus*), the western strawberry root weevil (*D. ursinus*), and the Lacomb strawberry root weevil (*D. wilcoxi*).

**Description**

The black strawberry root weevils are all evenly sculptured with low, rounded protuberances. None of these weevils are able to fly and all possess plainly visible snouts or beaks.

The strawberry root weevil is the smallest of the three, measuring about 1/5 inch in length. It varies from black to light brown in color.

The rough strawberry root weevil is about 1/4 inch in length and is generally of an even dark chocolate brown color.

The black vine weevil is the largest weevil of this group, measuring about 2/5 inch in length, and is black in color. Some individuals are marked with small flecks of white.

The gray strawberry root weevils are all about 1/4 inch in length. The decorated strawberry root weevil is gray in general color and is marked with whitish specks. The western strawberry root weevil is brown in general color and is covered with short fine hair. The Lacomb strawberry root weevil is brown in color and is covered with scales of a coppery sheen.

The larvae of both the black and gray weevils are white or pinkish legless grubs with a brown head capsule. All are semi-curled when in repose. They vary from 1/4 to 1/3 inch in length when full grown, depending on the species.

**Life history**

The seasonal history of the black root weevils is very similar for all three species. The eggs are laid on the ground under clods and other objects around the crown on the plants. The heaviest period of egg deposition is during June and July, although many eggs are laid as early as April and May and as late as August. The eggs usually hatch in about 10 days. The young larvae, upon hatching, burrow into the ground and at first feed on the fibrous roots of the strawberry plants and later transfer to the crowns where they feed on the outer surface and also tunnel within, often completely destroying the underground parts. The larval period generally lasts from midsummer until June the following year. Normally, most adults emerge at about the middle of the strawberry harvest, but in
Figure 1. Examples of strawberry root weevil species and stages. (1) Adult back vine weevil (3x). (2) Rough strawberry root weevil (3x). (3) Strawberry root weevil adult (3x). (4) Rough weevil adult pupa and larva. (5) Pupa of strawberry root weevil (4x). (6) Pupa and soil cells of the decorated strawberry root weevil.

mild years some adults emerge in late fall and overwinter. Others complete development in early spring and emerge during April and May.

The seasonal history of the gray strawberry root weevils is very similar for all three species. The adults emerge during March and April and lay their eggs during April, May, and June. The larvae
feed on the roots and crowns of the plants from May to August. They change to the adult stage during August and September and remain in the soil until the following spring.

Figure 2. Strawberry root weevil adults feed on the edges of the leaves. The most severe injury, however, is caused by the larvae feeding on the roots during the summer and early fall.
Injury

The injury of both groups of weevils is similar. The adults eat semicircular holes in the edges of the strawberry leaves and the larvae destroy the fibrous roots and crowns of the plants.

Control

Poison bait may be used to kill the adult weevils and thus prevent the deposition of eggs.

To insure good success when using bait, accurate timing of its application is necessary. It is not safe to make a hard and fast rule for timing of bait application for root weevils; but, in general, for the gray weevils the bait should be applied during April and for the black weevils about the time of the second picking of strawberries.

The following procedures will aid in making accurate timing of root weevil bait: (1) Examine the soil about the crowns of the plant for the immature forms during the spring months. If 75 to 90 per cent of the pupae have changed to the adult stage it is time to apply the bait. (Applicable for black root weevils only.) (2) Examine the top layers of soil and clods around the base of the plants (the weevils hide here during the day). If live weevils are found, baits should be applied. (Applicable for both groups of weevils.) (3) Examine the leaves occasionally for injury. If injury is evident, weevils can be found in the soil as in (2). (Applicable for both gray and black weevils.)

The number of applications of bait to apply will depend largely on the seasonal occurrence of adult beetles. In general, bait should be applied when live weevils are present in numbers. Excessive rains, especially during early spring, may necessitate the repeated application of bait if the poison is leached out before it can take effect.

Individual fields and parts of fields will vary greatly as to beetle population. Sometimes large populations are encountered adjacent to sources of infestation such as old strawberry plantings, fence rows, brush, and other places where suitable host plants occur. Much bait and time can be saved if these heavily infested areas are located early and baited. This will prevent spread to the remainder of the field. Also, it may make the baiting of the entire field unnecessary.

Several methods of application of the bait may be used. Broadcasting the bait by hand has proved to be satisfactory but is quite wasteful as the weevils are not apt to feed between rows. The placing of a teaspoonful of bait in the crown of each plant is the most economical and efficient method. A funnel may be soldered at the top of a light tin pipe and the device rigged for carrying. Bait can be
Figure 3. Strawberry root weevil grubs in heavy infestations may tunnel in the crown as shown. The more common injury is destruction of the fibrous roots.

dropped through such a device and accurately placed on the plant crown without bending over. The amount of bait applied per acre will depend on the method of application and plant size but 100 pounds will usually suffice for 1 to 3 acres.
Figure 4. Life stages of the decorated strawberry root weevil. (1) Adult of *Dyslobus decoratus*. (2) Pupae and pupal cells of *D. decoratus*. (3) Eggs of *D. decoratus*. (4) Larva of *D. decoratus*. (5) Pupa of *D. decoratus*. 
There are a number of proprietary baits on the market, most of which will give good control. Most of these use some type of fruit waste produce as a carrier for the poison. The poisons generally used are sodium fluosilicate or calcium arsenate. Baits containing 5 per cent of active insecticide were effective in field trials.

Home-made bran bait can be made on the farm and has proved entirely satisfactory for weevil control. The formula for making such a bait is as follows:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bran</td>
<td>50 pounds</td>
</tr>
<tr>
<td>Water</td>
<td>5 gallons</td>
</tr>
<tr>
<td>Sugar*</td>
<td>10 pounds</td>
</tr>
<tr>
<td>Calcium arsenate or sodium fluosilicate</td>
<td>5 pounds</td>
</tr>
</tbody>
</table>

The above bait may be mixed by dissolving the sugar in the water, incorporating this with the bran, adding the poison, and mixing thoroughly. Also, the sugar and poison can be dissolved in the water together and then thoroughly mixed with the bran. Either method has proved satisfactory.

**Spittle Bugs**

*Philaenus leucophthalmus* (L.) and *Aphrophora permutata* Uhl.

Two species of spittle bugs are commonly found on strawberries in Oregon. The meadow spittle bug (*P. leucophthalmus*) is by far the most common and destructive. The rhubarb spittle bug (*A. permutata*) is common but has never become a serious pest.

In the Willamette Valley the meadow spittle bug has been known to cause a one-half to as much as one ton reduction in yield per acre. This pest has many other cultivated and wild host plants, but its chief economic damage is to strawberries.

**Description, life history, and injury**

The adults of the strawberry spittle bug are grayish-brown in color and are about a quarter inch in length. The nymphs or immature forms are whitish to lemon yellow in color and are covered with a white, frothy spittle that they secrete and under which they feed. These nymphs suck the juices out of the leaves and fruit spurs, thereby causing them to become distorted and stunted. It is not uncommon to find 100 to 200 of these pests per plant. This injury is reflected in reduction of yield and often in inferior quality of fruit. The spittle bug has but one annual generation. The bugs reach maturity during May and June and lay their eggs from July.

* Molasses at the rate of 2½ gallons in this formula may be substituted for the sugar. When molasses is used the amount of water is reduced to 3½ gallons.
to as late as December and January. The eggs, which are yellowish orange and covered with a white cottony substance, are laid on the stalks of leaves, fruit spurs, and other protected places on the plant. The eggs hatch during late March, April, and May.

The rhubarb spittle bug has much the same life history as the meadow spittle bug. The adults are grayish brown in color and are about \( \frac{3}{8} \) inch long. The nymphs are bright red in color.

Figure 5. Spittle bug adults (Froghoppers). Left: meadow spittle bug. Right: Rhubarb spittle bug. The smaller form, being more numerous, causes greater injury to strawberries. (Magnified 7 times.)
Control

Application of certain insecticides to the young spittle bugs kills them even though they are under a mass of spittle. The insecticidal dust should be applied after the tiny yellow nymphs have all appeared and before the oldest nymphs are half grown. This period is in the last half of April in normal years.

Power driven dusters are best to use for control as the dust blast penetrates to the tender young central growth and bottom of the leaves where the nymphs congregate. Hoods at the end of each nozzle will help to confine the dust so that it penetrates to the young growth. Hand dust application is not very effective and must be repeated several times. A recurved discharge outlet on a hand duster will aid in getting the dust on the bottom side of the leaves.

Rotenone at the strength of a half or three quarters of a percent active ingredient has been used for many years to control spittle bugs in Oregon. It should be used at the rate of 50 pounds per acre. It remains effective against the nymphs for three to seven days depending on the amount of sunlight (which hastens its chemical decomposition) and the amount of forceful rainfall which washes part

Figure 6. The feeding of spittle bugs on the fruit clusters causes a shortening of the stems and unevenly developed fruit, which may make it unmarketable. Left: Injured clusters. Right: Normal clusters.
The damage has been done. Spittle bugs, after feeding about 6 weeks, change to the adult froghoppers before taking flight.

Rotenone deteriorates in storage. As a result, year old dust is not very effective.

An insecticide which has given excellent control of spittlebugs in field trials is “Methoxychlor.” The use of one application of 50 pounds of the 5 per cent chemical per acre was effective. It does not deteriorate in storage and remains effective in killing the nymphs for three to four weeks unless removed by severe rain storms.
Methoxychlor is somewhat poisonous to human beings so it should not be inhaled to excess or put in the mouth. Where spider mites are present the use of methoxychlor dust may cause an increase in the mite population.

Figure 8. A power machine used for dusting large acreages. The hoods serve to confine the dust to the plants as it is delivered and to insure a more thorough coverage.

Strawberry Crown Moth

*Synanthesdon rutilans* (Hy. Edw.)

The strawberry crown moth is one of the most important insect pests of strawberries in Oregon. It is widely distributed in the strawberry-growing areas and attacks cultivated and wild strawberries. It is occasionally a serious pest of blackcap raspberries.
Description

The grub of this moth is nearly one inch in length when full grown and is white to pinkish in color, except for the head which is brown. The thorax bears three pairs of legs and the abdomen bears five pairs of small brown hooked appendages arranged to make oval areas on segments three, four, five, six, and ten.

The adult is a clear-winged day-flying moth and greatly resembles one of the ordinary yellow jackets in color and size.

The eggs are brown in color, oval in outline, have a reticulate surface, and are about 1/50 inch long and 1/70 inch wide.

The pupa or resting stage is enclosed in a tube constructed of silk covered with brown frass, greatly resembling finely ground graham cracker crumbs.

Life history

There is one generation a year. It passes the winter as nearly full grown larvae in the crown of the strawberry plant. In the spring the larvae complete their growth and change to the resting stage in May and June. The adults emerge from June to early August and lay their eggs generally on the undersides of the leaves near the crown of the plant.
Injury

Plants infested with this pest often appear sickly and in many cases are killed outright. The larvae mine in the crown of the plant, often completely destroying it and reducing it to a mass of brownish frass. The pupal cases can often be found extended from the crown of the plant during the time the moths are in evidence.
Control

No adequate chemical means of control have been found for this pest. Several cultural methods of control have been found to be of value. One means of reducing infestation is to top the strawberry planting directly after harvest, leaving several rows untopped. The moths on emergence will concentrate most of their eggs on the untopped plants; these plants should be plowed up and destroyed after the middle of August. Removal of the foliage from the plants and its disposal by burning or burying will eliminate most of the surface where the moths normally lay their eggs. Care should be taken to avoid injury to the crown of the plants.

Where new plantings are started near old infested ones, a barrier strip of grain, such as barley or oats, planted between them will confine the moths largely to the old plantings. The moths usually fly very low and hesitate to cross these barriers. The barriers should not be destroyed before mid-August. When old strawberry plantings, which are to be destroyed, are near new plantings the old plantings should be deeply plowed under as soon after harvest as possible to prevent emergence of the moths as a nucleus of infestation for the new planting.

Strawberry Aphid

Capitophorus fragaefolii (Ckll.)

The strawberry aphid is important, because it can transmit virus diseases of strawberries. It is found throughout the state where these berries are grown commercially. It has also been found to infest wild strawberries, five fingers (Potentilla spp.), and wild roses. These last-named plants may serve as alternate hosts or virus reservoirs, but neither point has been definitely established.

Description

The wingless form of this aphid are generally yellowish in color. The winged forms are light green with blackish markings on the head, thorax, and abdomen. They are extremely small and hard to find on the plants. The eggs are shiny black and oval in outline and are laid on the undersides of leaves of strawberries.

Life history

The life history of this aphid is incompletely known for Oregon. Studies in the Willamette Valley have been started. Observations have been made in other parts of the state. From these data, it is evident that the seasonal history varies for different localities.
Apparently, the eggs are laid during late fall and winter. They hatch during February, March, and April. Winged forms first appear about May 20 and flight continues through July. The peak of flight is reached about mid-June. Populations during August, September, and October are very low. During late fall, winged females and males appear and the overwintering eggs are produced.

Injury

No true aphid injury has been observed as a result of feeding of this pest. The transmission of virus diseases of strawberries is apparently the sole harm caused by this aphid.

Control

Results of 1942 control studies indicate that this aphid can be controlled by means of insecticidal dusts consisting of a .75 per cent rotenone and 3 per cent soybean oil diluted with frianite. An alternate dust consists of 3 per cent actual nicotine diluted with hydrated lime. These dusts should be applied at the rate of 35 to 40 pounds per acre.

The recently introduced chemical "Parathion" has given excellent control of the aphids in greenhouse tests. One per cent parathion dust killed all the aphids on the plants between one and two hours after application. The complete control lasted for 10 days and then declined gradually to only 36 per cent control after 30 days when the plants were periodically reinfested. Parathion gave both the quickest and most persistent kill of aphids of the several insecticides tested.

It is suggested that hooded dusters be used in field applications of parathion to obtain a thorough coat of dust on the bottom side of the leaves. Application of 20 to 40 pounds of the 1 per cent parathion dust should give good field control. Growers should follow the recommendations of the insecticide manufacturers in regard to dosages, safety, and application procedures.

Parathion is poisonous to people and farm animals when misused. Men who apply parathion should avoid excessive dust in the face or on the skin. A safe respirator should be worn where exposure is unavoidable. In case of unusual dizziness, headache, or stomach disorder the applicator should consult a physician at once.

According to the best information available, dusting should begin about May 1 and be repeated at 15-day intervals until the end of July in order to control the winged aphids on new, nonbearing plantings. On bearing plants the parathion dust should be applied from May 1 until not later than ten days before harvest time and not at all
during harvesting. Bearing fields may be dusted after harvesting of the fruit is completed.

The relation between the aphids and the spread of strawberry viruses is complex and not yet fully worked out for Oregon conditions. Control of aphids may not reduce field virus spread under Oregon conditions. Among the relations that are known is the relation of winged aphids to virus spread. The winged aphids are the important means of virus spread from field to field. When the aphid population is low the winged aphids are scarce. Reduction of the aphid population should in turn reduce the winged aphids and cut down field to field virus spread. There is a possibility that aphids flying into a dusted field will live long enough to transmit at least some strawberry virus. For that reason, the aphids should be controlled so that winged forms do not appear.

Strawberry viruses are discussed in the section on strawberry diseases in this bulletin.

Omnivorous Leaf Tier

Cnephasia longana (Haw.)

The omnivorous leaf tier is widely distributed in the northern part of the Willamette Valley and attacks a large variety of hosts. For unknown reasons, it is more serious on berries in certain localities than in others.

Description

The adult moths have a wing spread of about ¾ inch. The male has an even grayish-yellow color while the female is grayish, mottled with brown spots.

The full-grown larva is about ¾ inch in length and grayish-yellow in color. It possesses two light and a distinctly darker central stripe on the back.

The eggs are salmon red in color when first laid and become lighter with age.

Life history

The adult moths emerge from late May to late June and deposit eggs through most of July. The eggs are laid on the bark of trees and other more or less rough surfaces. The eggs soon hatch into small larvae that spin small silken webs in which to overwinter near where the eggs were laid. In early spring, beginning about the first of March as a rule, these young larvae are carried to suitable hosts
on silken threads by air currents. For a time these minute larvae mine the leaves of low growing plants such as clover, vetch, and plantain. On emerging from the mines they migrate to flowers and the tender tips of many kinds of plants.

Figure 11. The strawberry fruitworm tunnels in ripe berries.
Injury

The injury by the larvae to strawberries consists of webbing together some of the blossom petals and feeding under the webbing on the green simple pistils at the surface of the developing berry. As the fruit matures the larvae tunnel into the base of the ripest fruit between the calyx and the berry-proper. They defile the fruit with their presence and decay often starts at the point of injury. Some of the worms may be carried into the canneries in the first picking of berries.

Control

There are three cultural means of obtaining partial control of the larvae. First, the strawberry grower may cut and remove rough-barked trees such as Douglas-fir, oak, and ash from the west side of his field. Such procedure removes the local source of the overwintering larvae if done before February. Second, he may avoid planting strawberries on the east side of such trees or unpainted wooden buildings and thus avoid most of the larvae. Third, he may plant a nonlegume crop preceding strawberries. The overwintering local larvae population will be low where a nonlegume such as grass, grain, or a cultivated row crop is grown. The greatest populations are built up on common or Willamette vetch. Natural control measures may be used in areas of severe infestation to supplement chemical control.

Chemical control has been found effective when a 5 per cent methoxychlor dust was applied twice in the spring to the plants with a hooded power duster. The dust should be applied at the rate of 50 pounds per acre. The first application time is about 15 days after the Marshall strawberry blossoms appear—in normal years, about April 20. A second methoxychlor application should be applied from two to three weeks later. At that time, the largest green berries will be about a quarter of an inch in diameter. Methoxychlor is slightly poisonous to people and should not be applied to the fruit less than two weeks before picking time.

The first application of methoxychlor dust should begin control of the omnivorous leaf tier larvae and also control spittle bug nymphs.

Cyclamen Mite

_Tarsonemus pallidus_ Banks

The cyclamen mite has been found to be of consequence only in the irrigated strawberry-growing areas of Oregon. To date, it has not been known to do serious damage in the Willamette Valley.
Description, life history, injury

This mite is extremely small and barely visible to the naked eye. The entire life cycle is spent on the strawberry plant. The greatest rate of reproduction occurs during the spring and early fall months. The injury consists largely of a general stunting of the plant and distortion of the leaves, especially the new growth.

Control

No field control measures have been developed.

The following procedures will materially aid in reducing damage by this pest: (1) Plant stock that is known to be free of mites. (2) Rogue out all infested plants as soon as they appear in the field. (3) Free planting stock of mites by treating with hot water at 110°F for 20 minutes or 108°F for 30 minutes. Great care must be taken not to reinfect treated plants by placing them in unsterilized containers, etc., before planting. Care should be exercised to prevent continued heating of planting stock after heat treatment.

Strawberry Crown Miner

*Aristotelia fragariae* Busck

This pest is present in most of the strawberry sections of Oregon and is commonly found along with the strawberry crown moth.

Description, life history, injury

The adult moth is brownish black with distinct yellowish scales on the forewings. It has a wing expanse of about ¼ inch. The full-grown larvae is about ½ inch in length, slender, and generally pinkish in color. The eggs are whitish in color and are laid on the sheaths about the crown, undersides of leaves, and on the leaf stalks.

The life history of this pest has not been completely worked out, but apparently it very closely parallels that of the crown moth.

The injury consists of small winding tunnels in the crown of the plant. Occasional larvae have been found mining the growing tip of the crown and also the leaf stalks.

Control

No definite control program has been worked out for this pest but studies indicate that topping plants as recommended for the crown moth has helped materially in reducing infestations.
Strawberry Leaf Rollers

Ancyliis comptana fragariae (W. & R.) and Comsolechia fragariella Busck

Two species of leaf rollers are commonly found on strawberries in the Willamette Valley: namely, the strawberry leaf roller Ancyliis comptana fragariae, (W. & R.) and the western strawberry leaf roller Comsolechia fragariella Busck. Neither species has become of major importance to date.

Description and life history

The strawberry leaf roller moth has a wing expense of about 1/4 inch and is rusty red in color with white markings. The larvae are brown to greenish in color, about 3/4 inch long when full grown, and very active. The eggs are flattened disks and are laid on the undersides of the leaves.

The leaf roller spends the winter as a nearly full-grown larva, and moths appear the following spring in April and May. There are several generations a year.

The western strawberry leaf roller moth has a wing expanse of about 3/4 inch, is brown in color with a silvery sheen, and has a darker transverse band beyond the middle of the wing. The larvae are white to cream in color, are marked with minute black dots, and are about 1/4 inch long when full grown. The eggs are oval in outline and laid on the undersides of the leaves.

This insect spends the winter in the egg stage on old strawberry leaves. These eggs hatch during the latter part of April, and the moths appear during late July to lay the overwintering eggs. This species has only one generation a year.

Injury

The injury of these two species of leaf rollers is very similar. The leaves are fastened or rolled together and tied with silk. The larvae feed inside this protected covering. When infestations are severe the plants have the appearance of being scorched.

Control

Parathion has given some growers control of the strawberry leaf roller when applied just as the injury starts. If needed, it may be used at least two weeks before harvest starts at the rate of two pounds of 25 per cent wettable powder to 100 gallons of spray, or as a 1 per cent dust.
Strawberry Leaf Beetle

Timarcha intricata Hald.

In a few instances the strawberry leaf beetle has been known to cause more or less serious injury to strawberries in the Willamette Valley, but ordinarily it is of minor importance.

Description, life history, injury

The adult beetles are jet black in color, rounded in outline, and about \( \frac{1}{4} \) inch in length. The larvae are hump-backed, greasy, grayish black in appearance. Both the adult and larva feed on the foliage during April and May.

Control

If damage becomes severe, lead arsenate used at the rate of 3 pounds per 100 gallons of water when the feeding is in progress should give control. This spray should not be applied after fruit has set.

Minor Pests

Flea beetles

Altica sp.

In some parts of the state, small blue flea beetles about 3/16 inch long with their greasy, blackish larvae have been found to do considerable injury to strawberries. Both the adults and the larvae skeletonize the leaves, sometimes defoliating younger plants.

If damage becomes severe, lead arsenate used at the rate of 3 pounds to 100 gallons of water should give control. This spray should not be applied after fruit has set because of poison residue.

Flat-headed borer

Chrysobothris sp.

This pest is quite abundant in several localities in Oregon. The larvae are white to cream in color and have a very much enlarged anterior body region. They are depressed in cross-section and form flat winding mines in the crown of the plant. The adults are flat, blackish beetles, more or less oval in outline.

No control measures have been developed. Good cultural practices that keep the plants in a healthy growing condition will aid materially in preventing infestations by this pest.
White grubs
*Polyphylla decemlineata* (Say) and *Serica* sp.

The larvae of the so-called June beetles are occasionally destructive to strawberry plants, especially on light, sandy soil. Infestations seem to be heaviest when strawberries immediately follow grain crops in rotations.

The grubs are curved in outline when in repose. They have three pairs of legs and a brown head and are generally of a dirty white color. The posterior end of the body is generally filled with soil particles that show through the skin of the larvae. Injury consists of the destruction of underground plant parts.

No satisfactory control measures other than digging and destroying infested plants have proved effective.

Common red spider
*Tetranychus* sp.

The common red spider occurs occasionally in damaging numbers on strawberries in Oregon, especially during dry summer weather. The injury consists in discoloration of the leaves due to the feeding of the mite and unsightly webbing on the undersides of the leaves.

No satisfactory control on strawberries has been found. A 1 per cent dust of dicyclohexylamine salt of DN applied when temperatures range below 75° F. has been suggested as a control.

Other minor pests

Slugs have often been reported feeding on strawberry fruits that are in contact with soil. Dry soil conditions and general clean-up of debris decrease the damage of these pests. Metaldehyde bait is an effective chemical means of control.

Thrips of several species are often found in the flowers and sometimes on the fruit, but they have not become of any importance to date.

Darkling beetles, ground beetles, and other soil inhabiting insects are often found in fruits. The only suggestion as to control that can be offered is to examine the berries at harvest and throw away contaminated fruit. Crates containing fruit should not be stacked directly in contact with the soil as soil insects and other vermin often seek such dark, cool places in which to hide.
Diseases of Strawberries

The common diseases of strawberries in Oregon are briefly discussed under four general groups according to the causal agents; namely virus, fungus, nematode, and physiological diseases.

Virus Diseases

Virus diseases (crinkle, yellows, etc.) are widespread in Oregon and especially throughout the areas of the state where strawberries have been produced commercially. The infectious materials are dissolved in the plant juices and are carried to all parts of the plant in the water conducting system. If a mother plant becomes infected all the runner plants from it will also become infected. One of the principal ways the virus diseases are spread is by the propagation of infected stock. Viruses are transmitted also by the strawberry aphid, which sucks infective juice from diseased plants and may inject it into healthy plants.

If only a single virus is present in a plant the effect may be very slight, and the productivity of the plant may not be greatly reduced. When more than one virus is present, however, a very serious disease may result; the productivity of the plant may be drastically reduced and its probable period of usefulness shortened.

Figure 12. Two Marshall strawberry plants of the same age. Healthy plant (left) on which aphids from healthy plant had been placed at the same time aphids from a crinkle plant had been placed on the plant to the right. (See Figure 13.)
Figure 13. Runner plant potted while still attached to mother having crinkle. Symptoms on first leaves are severe. When well-rooted, a leaf (largest) was produced without symptoms; but the youngest leaf showed primary symptoms as the plant became pot-bound. In the same way, young plants in the field show no symptoms during the first few months after planting, although they may be infected.

The symptoms of virus infection depend upon which virus or combination of viruses is present, upon the strawberry variety, and upon such factors as temperature, nutrition, and the number of hours of darkness and light. They may range from inconspicuous stippling of the leaves which is visible only in the late fall, to streak-
ing, crinkling, and malformation of the leaves, shortening of petioles, yellowing, and dwarfing of foliage, and a gradual “running-out” of the stock. Virus diseases seldom kill the commercial varieties of strawberries but they do make them unprofitable.

Virus diseases may be controlled by (1) use of virus-free planting stock, (2) isolating new fields of strawberries as far as possible from existing fields, and (3) reducing the chances for spread of the disease by spraying or dusting for the control of aphids.

Fungus Diseases

Leaf Spot

*Mycosphaerella fragariae* (Tul.) Lindau

One of the most familiar diseases of strawberry in Oregon is leaf spot. At first, the spots caused by infection of the fungus are a dark reddish or purplish color, but as they grow older the center of each spot becomes grayish or almost white. Fully developed spots are usually not more than \( \frac{1}{4} \) inch in diameter, with a whitish center and a distinct reddish border (Figure 14). The spots are irregularly scattered over the leaf surface and sometimes may destroy considerable of the functioning leaf tissue. The usual damage due to this disease, therefore, results from the loss of needed leaf surface.

Figure 14. Leaf spot.
Infection takes place during a rainy or very foggy period. Leaf spot, therefore, usually does not show up seriously during the height of the season in Oregon strawberry fields because of the lack of summer rains. As a rule the effects of the disease are so slight that no spray is recommended in the Willamette Valley. If a thorough job is done when the leaves are removed for the control of crown moth, the grower will have gone a long way toward keeping the disease to a minimum. Along the Coast, where rains and fogs are more frequent during the growing months, it is desirable to spray with bordeaux mixture 3-3-50 as soon as the growth is well started in the spring and repeat as often as necessary to keep the foliage well covered until the first berries are about one-third grown. Another application of bordeaux 4-4-50 before the first rains in the fall is also beneficial. (For preparation of sprays see Bulletin 393, Oregon Agricultural Experiment Station.)

**Scorch and Leaf Blight**

Scorch\(^1\) and leaf blight\(^2\) are two other fungus leaf spots abundant on wild strawberries in Oregon, but they seldom infect cultivated varieties. Scorch is commonly found in the Hood River Valley, and sometimes on Redheart and certain newer hybrids in the Willamette Valley. Neither disease does enough damage, however, to call for control by sprays, although sprays applied for the control of leaf spot will be effective against these two diseases.

**Red Stele (or Brown Core) Root Rot**

*Phytophthora fragariae* Hickman

The red stele root rot of strawberries is widely scattered in strawberry-producing districts of western Oregon.

The color of the core of a diseased root varies at different stages in the development of the disease in white roots. The color changes from pinkish to reddish, then brownish, and finally almost black. Brown, however, is the predominant color of the core of diseased roots. All or only a few of the main roots on a plant may show this symptom. It may be seen very early in the spring and as late as June or July. Diseased roots may be recognized by stripping with the thumbnail or cutting with a knife so as to expose the core (Figure 16). At first, the outer part of the root remains white, but it finally dies—usually starting at the tip and progressing up the root until the whole root decays.

When growth starts in the spring, infected plants grow very little or not at all, depending on the degree of infection. The leaves

\(^{1}\)Caused by *Diplocarpon earliana* (E. and E.) Wolf.

\(^{2}\)Caused by *Dendrophoma obscurans* (E. and E.) Anderson.
Figure 15. *Left*, normal strawberry plant; *right*, plant affected with red stele root disease. Note the absence of small feeding roots in affected plant, as compared with the normal root system. (Photo by U. S. Department of Agriculture.)
usually turn a characteristically red color early in the season. When warmer weather appears, severely infected plants wilt and die. The wilting is the response of the plant to the invasion of the water conducting tissues of the roots by the fungus parasite. The root system is seriously depleted, leaving mainly the larger roots, which are long and tapering and decayed at the lower ends, and which usually have no branches.

The red stele disease is caused by a fungus that is active during cool, wet weather. It doubtless attacks the roots soon after the fall

![Figure 16. Strawberry roots affected with the red stele root disease. A, diseased roots showing dead, discolored tip ends; upper portion of roots not discolored. B, diseased roots split lengthwise to show reddened central portion. C, normal roots split lengthwise to show absence of red center. (Photo by U. S. Department of Agriculture.)](image-url)
rains begin and is active so long as there is plenty of water in the soil. The fungus has motile spores that swim in soil water. Therefore, the disease spreads most rapidly in soils that readily retain moisture. For this reason the disease spreads, persists, and is most severe in heavier soils or in locations that lack drainage. Only rarely is a whole field of strawberries infected, and usually infection is limited to lower areas, at least to well-identified spots. In this respect red stele is distinct from black-root rot caused by Rhizoctonia. The latter does its worst damage in hill-land soils that are lighter. After once established in soil, the red stele disease will persist for many years in spite of crop rotations.

The red stele disease spreads from diseased to healthy strawberry plants by means of the motile spores of the fungus swimming in the soil water. The principal initial source of the disease, therefore, lies in infected planting stock. Consequently, the grower should be as sure as possible that his planting stocks come from fields free of the red stele disease. Control by spraying or dusting is hopeless. The use of Oregon Certified planting stock, produced in disease-free soils, is therefore advised.

None of the strawberry varieties used commercially in Oregon seem to be resistant to the red stele disease. Tests of known varieties and efforts to breed new ones resistant to the disease are now in progress at Oregon Agricultural Experiment Station.

It is essential that growers select a deep, easy-working, well-drained soil for strawberry plantings and avoid the heavy soils that remain watersoaked during a rainy season.

Other root rots

Strawberry growers have sustained heavy losses in various parts of the state from root diseases other than red stele. The condition generally known as "root rot" or "black root" has been shown to result from various causes. Drying out of the roots is one of the most important. In addition, a number of species of fungi are capable of causing "black root" when conditions are favorable. The fungi that seem to be responsible for most root rot lesions in Oregon are *Fusarium*, *Ramularia*, and *Rhizoctonia*. Without culturing out the causal organism, it is impossible to distinguish these diseases.

The usual symptoms of root rot are black lesions on the roots (Figure 17). The darkening at first is limited to the cortex with the core remaining white. Later, the entire root becomes darkened. Affected plants have an unhealthy appearance, and the color of the leaves is light green. When most moisture is needed about fruiting time, the plants are liable to wilt, especially in sunlight.
Figure 17. Rhizoctonia lesions on roots of Marshall strawberry.
The only known remedies for such a disease are: (1) selection of planting stock from fields with little or no infection, (2) careful handling of the plants to prevent drying of the roots, and (3) crop rotation. Strawberries should not be planted on land where crops susceptible to the fungi that cause root rot have been grown for at least two years. Other susceptible crops include potatoes, tomatoes, eggplant, black raspberries, and other crops.

**Mildew**

*Sphaerotheca humuli* D. C.

Strawberry mildew is destructive locally in Oregon. It is most easily recognized by the curling upward of the sides of the leaves. This exposes the underside, which usually is grayer in color than the upper side. This grayness and the whitish mildew powder (fungus) on the leaves gives to the whole patch a distinctly grayish appearance. Affected leaves later turn purplish or reddish. Where strawberries are irrigated, not only does mildew attack the leaves, but the fruit may also be seriously mildewed. Some of the common varieties listed in order of susceptibility to mildew are: Narcissa, Marshall, Corvallis, Redheart, and others.

No systematic experiments for the control of strawberry mildew have been conducted by the Oregon Agricultural Experiment Station, but field observations have shown lime sulfur to be effective. Where strawberries are grown in orchards under irrigation, for example, lime sulfur applied to the trees may be sufficient to keep mildew in check. Dusting with ordinary sulfur during warm weather is an effective control.

The New York Experiment Station has demonstrated that four applications of 8-15 lime and copper sulfate dust will give practical control of mildew even during seasons of maximum infection. Applications are about every 12 days, beginning when the first leaves start to expand. Sanitary measures such as destruction of the old leaves after harvest are beneficial.

**Armillaria Crown Rot**

*Armillaria mellea* Fr.

Plants infected with this mushroom crown rot become dwarfed and the leaves yellowish, and the whole plant wilts early in the summer. The cambium layer of infected crowns is usually replaced by a fungus "felt," and the core of the crowns is grown through with fungus. Interspersed in the fungus felt are islands of brownish plant tissue.
Scattered individual plants may be infected on recently cleared land, but usually circular areas where oak or other broad-leaved trees previously stood are killed by *Armillaria*. Infected areas should not be replanted with crops susceptible to the disease. Such crops are usually trees or shrubs.

**Fruit rots**

The shipment of fresh strawberries from Oregon is almost negligible. The crop from smaller plantings is used locally and that from the large commercial acreages is immediately canned or frozen. Thus, the Oregon crop does not suffer losses from many of the fruit rots as are often experienced in other localities after the berries are picked. There are several fruit rots known to be serious in the field. Of these, the gray-mold (*Botrytis*) rot is most important in Oregon. It occurs during and immediately following cool, damp periods. Due to this rot, losses are heavy when it rains during the ripening season. Even green berries decay during cool, wet weather.

Because this fungus grows well in warm or cool temperatures, berries on local markets are subject to considerable loss through gray mold if picked when wet.

Spraying or dusting methods, successful in controlling fruit rots in most tree fruits, have not proved practicable for strawberries. Year after year, fruit rot in the field is not of sufficiently regular occurrence to justify regular applications of spray or dust.

**Nematode Diseases**

Four groups of nematodes (eelworms, thread- or roundworms) produce diseases of commercial strawberries in the United States. Three of these groups are present in Oregon. Although nematodes may limit berry production to some extent, they are of importance chiefly to those growers who produce plants for sale. The best means for control at the present time are the planting of disease-free stock and avoidance of land known to be infested with any of the nematode parasites of strawberry.

**Root-knot Nematodes**

*Meloidogyne* sp.

Root-knot is the most serious and widely distributed nematode disease of commercial strawberries and planting stock in Oregon. The presence of galls on the root system is a good indication of the
Movement of planting stocks which harbor root-knot nematodes in their root system to noninfested areas is a potential threat to agriculture in general, because these parasites can...
Figure 19. Nematode galls on leaves and stems. This is one of the less important diseases of strawberries in Oregon.

attack more than 2,000 kinds of plants. Some states now enforce restrictive measures against the intra- and interstate movement of infested plant material.
Root-lesion Nematodes (Meadow Nematodes)  
*Pratylenchus* sp.

Recently, root-lesion nematodes have been found on strawberries in Oregon. The presence of the disease may be indicated by the appearance of unthrifty plants in certain areas of the field. The root systems of these plants are characterized by the lack of feeder roots and by dead areas on the larger roots. Although no restrictions govern the movement of infested plants, the growers of planting stock face a situation similar to that presented by the root-knot nematodes. Root-lesion nematodes also attack ladino clover, croft lily, narcissus, and numerous plants produced by the nursery and greenhouse industries.

Bulb and Stem Nematodes  
*Ditylenchus* sp.

Commercial varieties of strawberries are occasionally attacked by the bulb and stem nematodes, which usually produce severe distortion of the leaf and flower parts (Figure 19). The symptoms are most noticeable on the first leaves produced in the spring but tend to disappear on later growth. Injury to the fruit buds results in little or no berry production. Some common plants attacked by these nematodes are alfalfa, red clover, and narcissus. Such native hosts as potentilla, false dandelion, plantain, and wild strawberry also are susceptible.

The foliar nematodes (*Aphelenchoides* sp.), which cause spring and summer dwarf or crimp diseases, have not been found on strawberries in Oregon.

A Physiological Disease: Alkali Yellows

Strawberry plants thrive best in rich loamy soils that are rather acid in reaction, and most varieties are very sensitive to soils that are neutral or alkaline in reaction. A yellow color of the leaves is the most striking symptom of this latter condition. Such plants in very slightly alkaline soil may bear quite normally for a year or two but gradually dwarf. For the most part, the “alkali yellows” occurs in irrigated lands of eastern and southern Oregon. Any practical treatment to increase the acidity of alkaline soil will be helpful.
<table>
<thead>
<tr>
<th>Name of insect</th>
<th>Injurious form of insect</th>
<th>Where injurious form of insect found and type of injury caused</th>
<th>Stage and description of insect at which control directed</th>
<th>Time and timing of control measures</th>
<th>Control measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strawberry root weevils</td>
<td>Whitish, curled, legless grubs with brown head; $\frac{1}{2}$ to 1 inch long</td>
<td>In soil around roots and tunneling in crown of plant</td>
<td>Gray, brown, and black snout weevils found under soil and debris about plants in daytime</td>
<td>April to June—when beetles in evidence</td>
<td>Place in center of each plant one teaspoon of poison bait consisting of bran or dried apple pomace combined with calcium arsenate.</td>
</tr>
<tr>
<td>Strawberry crown moth</td>
<td>Whitish larvae (not curled) with 3 legs on thorax and small brown paired rings of hooks on venter of abdomen; $\frac{1}{2}$ to 1 inch long</td>
<td>Tunneling in and destruction of crown of plant</td>
<td>Yellowish, yellow-jacket-like, day-flying moths</td>
<td>June to August</td>
<td>Top plants after harvest, leaving several rows untopped, destroy untopped plant in fall. Young plantings adjacent to old infested plantings should have barrier strip of grain planted between and left until mid-August.</td>
</tr>
<tr>
<td>Spittle bugs</td>
<td>Yellowish to greenish insects concealed in spittle masses</td>
<td>On leaves and fruit clusters; deformed leaves and berries; reduction in yield</td>
<td>Insects in spittle masses</td>
<td>When spittle masses in evidence</td>
<td>Dust with 5 per cent rotenone in diatomaceous earth or 5 per cent methoxychlor dust.</td>
</tr>
<tr>
<td>Strawberry aphid</td>
<td>Plant lice</td>
<td>On leaves and stems; transmission of virus diseases</td>
<td>Plant lice</td>
<td>Flight period of aphid (May to July)</td>
<td>Use disease-free planting stock. Apply 75 per cent rotenone dust with 3 per cent soybean oil or 3 per cent nicotine sulfate dust or 1 per cent parathion dust during flight period.</td>
</tr>
<tr>
<td>Omnivorous leaf tier</td>
<td>Dirty yellowish, active caterpillar about $\frac{1}{2}$ inch long</td>
<td>Tying petals of flowers and tunneling in fruit</td>
<td>Young larvae</td>
<td>About May 1 and May 20</td>
<td>Apply 5 per cent methoxychlor dust to the plants at the rate of 50 pounds per acre.</td>
</tr>
<tr>
<td>Cyclamen mite</td>
<td>Adult and immature mites (nearly invisible)</td>
<td>Distortion of young growth as well as older part of plant</td>
<td>All stages (mites and eggs)</td>
<td>Before setting out new plants</td>
<td>Use hot water treatment of plants—110°F, for 20 minutes or 108°F, for 30 minutes.</td>
</tr>
<tr>
<td>Strawberry crown miner</td>
<td>Small pinkish caterpillars</td>
<td>Tunneling and destruction of crown of plant</td>
<td>Small, grayish moth</td>
<td>June to August</td>
<td>No definite control but topping of plants as for crown moth of some value.</td>
</tr>
<tr>
<td>Strawberry leaf rollers</td>
<td>Brownish to pinkish very active caterpillars about $\frac{1}{2}$ inch long</td>
<td>In folded and webbed leaves; skeletonizing and defoliation</td>
<td>Caterpillars</td>
<td>Poison sprays before fruit forms and after harvest</td>
<td>Use lead arsenate (3 pounds to 100 gallons of water) but not when fruit is present—topping plants as for crown moth may be of some value.</td>
</tr>
<tr>
<td>Strawberry leaf beetle</td>
<td>Black oval beetles $\frac{1}{4}$ inch long and humpback blackish greasy larvae</td>
<td>Defoliation of plant</td>
<td>Adult beetles and larvae</td>
<td>Poison sprays or dusts when beetles and larvae present</td>
<td>Use lead arsenate spray (3 pounds to 100 gallons of water) or 10 per cent lead arsenate dust; do not apply after fruit sets.</td>
</tr>
</tbody>
</table>
### Table 2. Control Chart for Diseases of Strawberries

<table>
<thead>
<tr>
<th>Name of disease</th>
<th>Type of injury produced</th>
<th>Control measures</th>
<th>Time to apply control measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viruses (Crinkle, Yellows, Stunt, Witches Broom)</td>
<td>Streaking, mottling, yellowing, wrinkling, and malformation of leaves. Petioles shortened, plants flat to the ground, dwarfed.</td>
<td>Use clean planting stock.</td>
<td>At planting time.</td>
</tr>
<tr>
<td>Leaf spots</td>
<td>Spots on leaves about $\frac{1}{4}$ in diameter, whitish centers with dark red or purple borders.</td>
<td>Burn old leaves; spray with Bordeaux 4-4-50.</td>
<td>Spring and fall.</td>
</tr>
<tr>
<td>Mildew</td>
<td>Mildews leaves and fruits. Leaves roll up and show reddish tone.</td>
<td>Dust with sulfur or spray with lime-sulfur (2-100).</td>
<td>Whenever mildew shows on leaves.</td>
</tr>
<tr>
<td>Armillaria crown rot</td>
<td>Plants wilt and die. Crowns filled with fungus tissue.</td>
<td>Dig out affected plants and destroy.</td>
<td>Whenever plants appear.</td>
</tr>
<tr>
<td>Red-stele root rot</td>
<td>Plants remain small. Leaves bluish green; reddened early. Roots have reddish brown core and decay at tips.</td>
<td>Use clean planting stock; select fields free from the disease; avoid low, poorly drained areas.</td>
<td>At planting time.</td>
</tr>
<tr>
<td>Other root rots</td>
<td>Plants wilt about fruiting time. Roots have blackened areas and few live roots.</td>
<td>Use clean planting stock. Rotate plantings.</td>
<td>At planting time.</td>
</tr>
<tr>
<td>Scorch</td>
<td>Small purplish spots on leaves.</td>
<td>No control needed.</td>
<td></td>
</tr>
<tr>
<td>Leaf blight</td>
<td>Large spots on leaves; center brown, borders dark purple.</td>
<td>No control needed.</td>
<td></td>
</tr>
<tr>
<td>Fruit rots</td>
<td>Decayed fruit, usually in the market or in cannery lugs.</td>
<td>Keep fruit cool and well ventilated.</td>
<td></td>
</tr>
<tr>
<td>Root knot nematodes</td>
<td>Knots or galls on roots.</td>
<td>Use clean planting stock. Avoid fields where nematodes are known to occur. Rotate crops.</td>
<td>At planting time.</td>
</tr>
<tr>
<td>Root lesion nematodes</td>
<td>Small, unthrifty plants. Few feeder roots. Dead areas on older roots.</td>
<td>Same.</td>
<td>Same.</td>
</tr>
<tr>
<td>Bulb and stem nematodes</td>
<td>Distortion of leaves and petioles.</td>
<td>Any method to make soil more acid.</td>
<td></td>
</tr>
<tr>
<td>Alkali yellows</td>
<td>Plants yellowed, usually under irrigation.</td>
<td>Any method to make soil more acid.</td>
<td></td>
</tr>
</tbody>
</table>