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Understanding Crop Pests

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What this book is about

The first part of this volume presents in brief the *life cycles* of all the most important crop insect pests in the United States. Knowledge of the life cycle is necessary to a clear understanding of the insect and the injury which is often done by it in its larvae stage. The second part of this volume provides brief descriptions and illustrations of the most common weed pests and fungus diseases of crops in the United States.

Your state agricultural college (see list in Volume Six) is your most *authoritative* source of information. Such authentic information is based on broad research and experiment. Use your state college which as a taxpayer you support. Get personally acquainted with the entomologists, plant pathologists, weed specialists and agricultural engineers. They will treat you cordially and give you valuable assistance. Always check specific dosages and timing carefully with them prior to treating any crop. Obtain their advice on all *new* chemicals.

The Air-Applicator Institute is most appreciative of and gives full recognition to the following persons for the excellent contributions which they have made to the general knowledge of insects and weeds. This volume also makes liberal use of the published bulletins of the various state agricultural extension services.

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Some of the insects and weeds described in this volume are not the type which can be adequately treated by air-application. They have been included, however, because every *air-applicator* eventually will wish to know about all common crop pests in order to properly analyze his customer's crop damage. Also many air-applicators are equipped to handle ground application as well. (See the illustrated bibliography in Volume Six for references for further study.)

Do not use any dosage recommendation without *first verifying* it with your local county agent or weed specialist or entomologist.

PART ONE

INSECT IDENTIFICATION

Insects today are man's greatest competitors in his struggle for existance. Insects destroy our crops, they kill our animals, they crumple our buildings and they actually feed on man himself. They spread disease germs that threaten both plants and animals. Some diseases, carried only by insects, have killed more people than have been killed in all wars.

Not all insects are harmful. Many are of little or no economic importance and some, such as ladybeetles, wasps and certain flies, are actually beneficial to man. There are about 700,000 different kinds of insects known to exist, all scientifically named and classified.

Types of Insects

For the purpose of air-application of insecticides, insect pests need be divided only into two general types — those that eat the plant foliage and those that suck the juices from the foliage. Insecticides similarly are divided into two classes — *stomach* poisons and *contact* poisons.

● CHEWING INSECTS get their food by chewing the foliage of the plants, particularly the leaves. If a stomach poison is on the leaf the insect gets the poison as it consumes the leaf. The efficiency of the poison and the amount the insect eats determines the killing effect. Fig. 2a shows a typical beetle type insect chewing leaf material and consuming the insecticide along with the food. Notice the chewing mouth parts. Codling moth, other moths, katydids, orange tortrix, holcocera, fruit tree leaf roller, cutworms, Fuller's rose beetle, cucumber beetle, sawflies, grasshoppers and crickets are examples of insects which bite off and swallow portions of fruit or foliage.

(A) (B)

FIG. 2.—A, Insect with chewing mouth parts; B, insect with sucking mouth parts.

● SUCKING INSECTS: Fig. 2b shows those insects that insert their bills into the stems or leaf ribs and draw the plant juices into their stomachs. Obviously, this type of insect is little affected by the film of poison on the surface of the leaf insofar as the food which enters his stomach is concerned. Aphids, mites, scale, thrips, potato leaf hoppers and the false chinch bug are examples of suck-

◊ Fig. 1. Grasshoppers on corn. Courtesy of United States Department of Agriculture, Bureau of Entomology and Plant Quarantine

ing insects. A *contact* or *respiratory* poison must be used to control these insects. A contact poison works in an entirely different manner than a stomach poison. Contact poisons are absorbed through the respiratory and the nerve system of the insect.

In the case of flies and mosquitoes, the legs are particularly sensitive to synthetical chemical substances. The feet are known to be carriers of taste, therefore, a mosquito or fly resting on a wall can be poisoned through this "tongue" in its feet. Many similar insects have sensitive pores in which the contact poison gets into their systems.

● LEARN TO IDENTIFY INSECT DAMAGE: When dealing with insects you are working in the technical field of *entomology*. Before you can identify and control insects, you will need to know about the habits and characteristics of the insect which you are attempting to control. Don't expect to find heavy populations of insects. Most destructive insects and worms are nocturnal, remaining hidden during the day and doing their feeding at night. By careful observation and study you can learn to look for types of damage.

It is important to know exactly where to look for insects. For example, leafminers, mites and aphids feed on the under side of the leaves. Air-applicators should be able to identify insect damage and advise growers accurately on the presence of pests and the proper methods of control.

IDENTIFICATION

Alfalfa Weevil

The adult stage of this insect, Figure 3, is a small brown weevil, or snout beetle, ⅜ inch long, which feeds on the leaves of alfalfa and related plants and lays its small, oval, yellowish-orange eggs in the stems of the plants. The mature larvae are legless, about ¼ inch long, and bright green, with a small black head and a white stripe down the back. The mature larvae spin thin lace-like cocoons in the debris at the bases of the plants, transform into pupae and eventually into adults. Figure 3 shows a cluster of eggs in an alfalfa stem and the larvae stage.

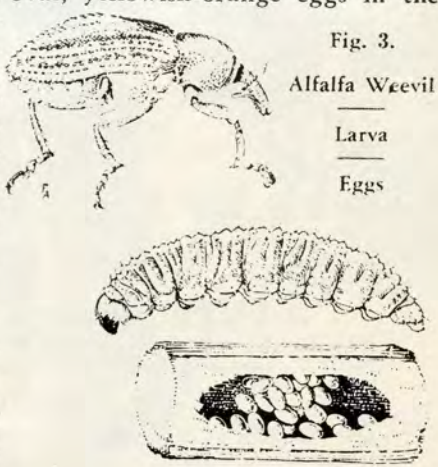


Fig. 3.

The adult alfalfa weevil hibernates through the winter in the crowns of the plants or other cover. During late April or May they emerge from hibernation to feed on young alfalfa or other

plants. Egg laying soon starts. The eggs are laid in the alfalfa stems, and when hatched, the young larvae or worms attack the new growth. The feeding period lasts for about 3 weeks. In severe infestations the plants may be stripped of leaves. The damage is done by the larvae to the first cutting of alfalfa, and to the new growth of the second cutting.152

Alfalpha Leaf Hopper

The adult insect is 1/8 inch in length, greenish in color, and wedge shaped. The young, or nymphs feed by sucking on the underside of leaves and also on stems. They are light green and are characterized by the ability to run sidewise, often disappearing quickly, to be found on the opposite side of the leaf. There are several generations each year. The winter is passed by hibernation of the adult. Eggs are laid in plant stem and leaves.

Aphis

There are many kinds of aphis. See Fig. 4. Their characteristics and habits, however, are very similar. Aphids are about 1/8 inch long, have fat bodies, thin legs and are green, black or brown. They insert beaks in leaves and suck vital juices. This causes curling and stunting of leaves. Aphids secrete a nasty black honeydew. Aphis attack practically all plants from indoor house plants to giant trees. They are particularly prominent on bedding plants. Nicotine, rotenone, pyrethrum, parathion, and dormant sprays are all useful in controlling aphids.

Fig. 4. Typical colony of aphis. Courtesy U. S. Department of Agriculture, Bureau of Entomology and Plant Quarentine.

There are three species of aphids that look very much alike. They are rosy apple aphid, green apple aphid and apple grain aphid. All of them overwinter in the egg stage, on twigs and in bark crevices. It is impossible to tell the different species by their eggs, because the eggs all look alike.

In the spring the young nymphs appear about the time the buds are opening and the leaves unfold they work down into the clusters and

suck on the small stems and newly formed fruit. As a result the apples remain small, misshapen, hard, knotty and puckered around the calyx. Infested leaves tend to curl and form clusters. The aphids leave the apple late in the spring and are supposed to spend the summer on narrow-leaved plantain. They return to the apple in the fall and produce eggs.

● APHIDS ON STONE FRUITS: There are several species of aphids that infest stone fruits. Their life history is similar. They pass the winter in the egg stage on the trees. The eggs hatch early in the spring and the young aphids begin feeding on the foliage. Usually they fly to other host plants during the summer and return to the trees in the fall to lay their over-wintering eggs. Large numbers cause the leaves to curl and can affect the vitality of the trees and fruit production seriously. 58

● CABBAGE APHID: The cabbage aphid has been recorded as infesting cabbage, cauliflower, brussel sprouts, kale, turnips, radishes, and many other related plants. The aphids suck the plant juices from the leaves, causing them to curl and form cups which may contain large numbers of the insects. In severe infestations the plant may wilt and die. If they are not killed, growth is usually slow; the plants may be dwarfed and not suitable for market.

The eggs are small, ovate, blackish in color and are glued generally to the stems or buds of plants. The nymphs are quite small, and are grayish green in color. There are two forms of adults: both are delicate, soft-bodied grayish green insects. One form has wings, the other is wingless. They are covered with a whitish, powdery secretion which gives them a dusty gray appearance.

In the fall fertilized females lay their eggs on the leaves and stems of the host plants and the winter is past in this stage. When the weather becomes warm in the spring the eggs hatch and the nymphs develop into wingless females, which produce their kind without mating. One female may produce as many as 50 to 100 active nymphs in a week or two, and this succession of generations continues throughout the summer. At times during this period winged forms may be produced which are able to fly to other plants and establish a succession of generations on them. 156

● WOOLLY APPLE APHID: The principal hosts of the woolly apple aphid are apple, pear and elm, and minor hosts are hawthorne and mountain ash. The principal injury is to nursery stock, young trees and ornamental elm.

The aphids collect in masses in wounds and on knots on the trunk and branches as well as the underground portions of the tree. Injury to the above ground portions of the tree are minor except for the sev-

ere curling and bunching together of the leaves on elm, giving the tree an unsightly appearance. The most severe injury is caused by feeding on the roots which results in the formation of many short fibrous roots and galls. This injury causes stunting and poor development which may lead to death of the tree.

The egg is tiny, black, and oval in shape. The young, called nymphs, are tiny, wingless, "leggy" crawlers nearly transparent but with a slight reddish tinge. The adult gets its name from the white, flocculent, waxy secretion that envelopes its body. Inside the cottony mass, the common forms are wingless aphids about 1/10 inch long and reddish or purplish in color. Winged individuals can be found throughout the summer, but these do not have the conspicious woolly covering.

The life histories of these two wooly aphids are somewhat similar. As in many aphids there is a complex cycle involving two hosts. Part of the year is spent on elm and part of the year on apple, pear or other host. Both the eggs and immature nymphs overwinter. The nymphs overwinter on the roots of the apple and the eggs in cracks or protected places on the bark of elm. In the spring the eggs hatch and the first two generations feed on elm during May and June. These two generations are wingless. A winged form is then produced which migrate to the apple and other hosts. Several generations appear on this second host. All these individuals reproduce by giving birth to living young without mating. In the fall wingless males appear and mate with wingless females and each female lays a single egg. 212

Boll Weevil

The boll weevil, see Fig. 5, is a destructive pest of cotton. It migrated from Mexico and has caused billions of dollars of damage since it was first found in Texas in 1892. The adult is a small, hard-shelled snout-beetle that overwinters in woods adjoining cotton fields. The weevil emerges in the spring over a long period. It eats small holes in the "squares" (flower buds) and then lays its eggs in the holes. The larvae developing from the eggs complete their growth in the squares which have fallen to the ground. Bolls also are attacked, but most of the injury is done to the squares.

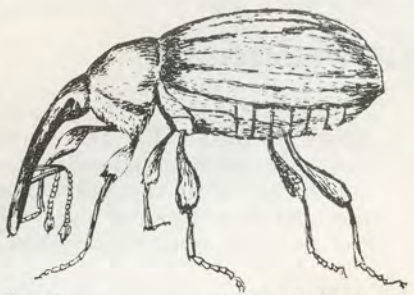


Fig. 5. Cotton Boll Weevil

As cotton must be treated every four to five days, dusting equipment should be on hand that will dust the entire acreage within that time, allowance being made for unfavorable weather and breakdowns. The airplane is particularly adaptable to meeting the need for speed and large scale application. 201

Cabbage Worm

The outer spread leaves of cabbage, cauliflower, and other crucifers are riddled with holes and the loose leaves are eaten in spots by the cabbage worm. Masses of greenish black excrement are left where the worms feed. In cases of very serious infestation the leaves may be so badly eaten that the plant never reaches maturity, or if so, is dwarfed. The eggs are glued to the underside of the leaf. They are visible to the naked eye, are bullet-shaped, yellow, and are covered by both lengthwise and encircling ridges.

The full grown caterpillar is a little over an inch long and is leaf green with a light orange stripe down the middle of the back and a broken stripe of orange along each side. It has a velvety appearance caused by a thick growth of silky hairs all over the body. There are three pairs of true legs and five pairs of false legs.

The pupa is a greenish, tannish or gray, rather naked looking chrysalis with some sharp points or projections along the middle of its back and also protruding from the front end. It can be found suspended by a few loose strands of spun silk from a leaf in the patch or from a building, fence post or some other object close by the host. The adult is the familiar white butterfly with a few black spots on the wings. It has a wing expanse of a little over two inches.. 155

This insect overwinters as a pupa and early in the spring the white butterflies emerge and lay several hundred eggs each on the underside of the leaves. The eggs are laid singly and are glued to the leaves. After about a week the eggs hatch and the larval stage lasts about two weeks. The larvae pupate and after one to two weeks a second generation of adults appear. There are three to six generations a year. 155

Caterpillars

The caterpillar is the second of four distinct stages of development which all butterflies and moths go through: egg, larva (caterpillar), pupa (chrysalis), and adult (moth). Damage is inflicted usually during the larval or caterpillar stage. Moths lay the eggs but do not damage, and they serve as a warning of the caterpillars to come. The control program must be directed against the caterpillars themselves.

The life histories of all of the caterpillars are somewhat similar. Eggs which have been laid on the plant by the adult moths, hatch after three to five days. The small caterpillars eat their way to maturity, casting their skins several times as they grow. During this period they do their damage to plant leaves, or fruit, each in his own way.

On completing development of larvae, the caterpillars begin construction of their pupal cells. Most of the pests of tomato will burrow into the soil, build there a few inches below the surface for the subsequent emergence of the adult moth.

The pupal stage varies in length for each of the different kinds of caterpillars, and also varies with the weather. For example, the corn earworm has a pupal period of two to three weeks during the summer but the fall broods will remain in this stage over winter.

When the pupal stage is over, the adult moths emerge, expand and dry their wings, mate, and after a day or two begin laying their eggs in great numbers. Usually at dusk on warm days the female moths of the corn earworm may be seen flitting here and there, seldom flying higher than the tops of the plants, and laying eggs at random over the plants. A single moth will lay 500 to 3,000 eggs during her lifetime.

With the hatching of these eggs another generation begins its life cycle. Some species, such as the tomato hornworm, will have three generations a season, but others, such as the tomato pinworm, will pass through as many as seven or eight generations in a year. 117

Cotton Boll Worm

The boll worm is the same species as the corn earworm and tomato fruit worm. Damage usually is done late in the season to the squares and bolls. Young worms feed on the tender buds and leaves for a short time after hatching. When a total of from 20 to 25 eggs or young worms per 100 plants are found, dusting should be started at once. The dust is much more effective if applied before the worms enter the boll. Cryolite is effective. Calcium arsenate or lead arsenate may also be used. Treatments should be repeated every 5 days until control is obtained. 201

SEE AGRICULTURAL EXTENSION PUBLICATION

NO. 1041

Louisiana Agricultural College, Baton Rouge, Louisiana, for full recommendations on control of the various cotton insects.

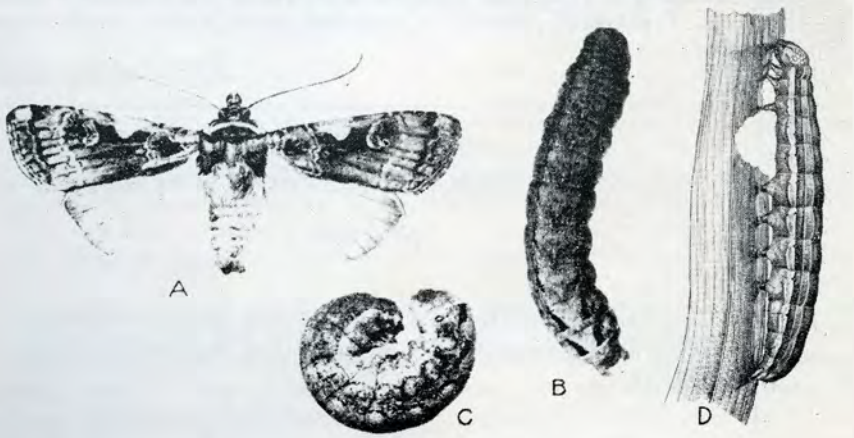
Cutworm

Almost all plants, except those with woody stems, are attacked by cutworms. See Fig. 6. Together with grasshoppers they are among the most general feeders. They are extremely injurious in home and market gardens. Plants are injured in several ways. The most common injury is caused by the solitary, surface cutworm which cuts off the plants near the surface of the soil. See Fig. 7. The climbing cutworms climb the stems of various herbaceous plants, vines, shrubs, and trees and eat the leaves, buds, flowers, and fruits. The army cutworms are those which occur in great numbers in a limited area and move in mass migrations from one area to another. The *subterranean* cutworms remain in the soil and feed entirely upon the roots and underground portions of the stems.

The eggs are small, usually globular in shape and are rarely seen. The larvae of the different species vary considerably in their markings but most of them have a greasy appearance. When disturbed they curl up in the characteristic watch spring position. Mature larvae may reach a size of almost two inches in length. They usually feed at night or on cloudy, dark days. The pupa is brown and is formed in a cell several inches below the surface of the soil. The adults are commonly called millers and are familiar to most persons by their habit of flying into lights at night.

Details of the life history vary with the different species but in general they overwinter as partly grown or fully grown larvae in cells in the soil, or under trash, stones, bark or other places which may af-

Fig. 6. Spotted Cutworm — Army worm. Courtesy of U. S. Department of Agriculture, Bureau of Entomology and Plant Quarentine.



ford protection. They start feeding in the spring and continue until they are full grown in early summer when they change to pupae and later emerge as adults. Most of the common species have only one generation but because of variations in the life histories of the various species all stages of development may be found throughout the season. 150

● CLIMBING CUTWORMS: In the spring, climbing cutworms often feed on opening buds and the developing fruit. They overwinter as partly grown worms in the soil. Cutworms become active in the spring and feed at night on the fruit buds and fruit. When full grown they build cells in the soil where they pupate. The moths emerge during the summer and lay eggs in the late summer or fall on trees or cover crops. The eggs hatch in the fall and the small worms feed for a time before going into hibernation. 58

● PALE WESTERN CUTWORM: The pale western cutworm feeds upon practically all field crops. Some of the most important host plants are small grains, corn, flax, many native grasses, tumbling mustard, and Russian thistle.

The larvae of this insect almost invariably eats the central stem of its surrounding sheaths ½ to 1 inch below the surface of the ground.

Fig. 7. Cutworm damage. Courtesy U. S. Department of Agriculture

The part of the plant above ground dies and in severe infestations the field may be entirely destroyed. The fact that only a small portion of each plant is eaten and then another plant attacked, makes this insect much more destructive than many other cutworms. Injury is generally noticed first on the higher spots in the field or where the soil is inclined to be light. The pale western cutworm occurs in states along the eastern slope of the Rocky Mountains, extending from northern New Mexico into Canada.

The eggs of the pale western cutworm are a dull gray color, quite small, oval in shape, and slightly flattened. The full grown larvae average about 1¼ inches in length. The head is light brown, the body is a light greenish-gray color and has a greasy appearance. The pupae are bare, about ¾ inch in length and brown. The head and thorax of the adult are gray. The front wings are dark gray with lighter and darker markings. The rear wings are whitish at the base with a dark band near the outer margin.

The pale western cutworm is a dry weather insect. The most severe outbreaks follow seasons of limited rainfall. Several methods have been developed for forecasting outbreaks with considerable accuracy. The first method is as follows: If there are less than 10 wet days during the period of larval activity (May and June) there is likely to be an increase in cutworm population. If there are between 10 and 15 wet days during this period there will probably be a decrease in the number of cutworms the next year, and if there are more than 15 wet days little cutworm trouble may be expected the following year. A wet day is when the fields are too wet to use a disc harrow. 194

● ARMY WORMS: Army worms are closely related to cutworms. They derive their name from their habit of traveling in hordes or armies in search for food. Infestations usually originate in the spring in fields of small grains and when the food supply gives out the caterpillars move to adjacent areas. The caterpillar, Fig. 6, is dark green marked with white stripes. They are usually about 1½ inches long. Army worms may be controlled with a lead arsenate dust or spray or poison bran bait similar to that used for cutworms.

Cherry Fruit Fly

There was a time when the cherry fruit fly, like many other insect pests, lived in the lush growth of wild fruits and berries in the forests. Transforming the forests into cultivated fields and orchards has caused the insects to migrate to the cultivated areas. Although reasonably well under control in most areas, a continuous spray program is needed to effect continued control. Oregon experienced its heaviest infestation in 1945. Hundreds of tons of its 4 million dollar cherry crop was rejected. One worm in a carload is sufficient reason for rejection. 101

The maggot of the cherry fruit fly passes the winter in the soil in small capsule like cases called puparia. It makes its appearance as a fly sometime during the last of May, and in some areas up to the first of July. The adult fly is black with a white stripe down each side. It is about one-half the size of a house fly.

After emerging they spend several days basking in the sunshine and feeding on the moisture and honeydew deposited on the foliage of the cherry trees. After about a week the egg laying period begins. The flies sting the skin of the cherry and deposit their eggs in the fruit. The young maggots hatch in from five days to a week and commence to feed through the pulp. The full grown maggot is about ¼ inch long without head or legs. They spend about 2 weeks tunneling their way out. They then drop to the ground and burrow down beneath the surface several inches, change to a small capsule like puparium and wait until the following spring to repeat the cycle. 101

● FRUIT FLY TRAPS: A highly effective fly trap was developed by a Washington Experiment Station last season. It will be employed this year to determine fly emergence. This trap contains ammonium carbonate, which attracts the flies. Several hundred traps will be supplied to the Horticultural Inspectors of the State Department of Agriculture. These men will place them in strategic areas in the orchards and make periodic inspections for fly emergence. Upon finding the first fly, this information will be sent to the County Extension Agents, who in turn will give the necessary publicity to growers. These traps are to be used solely to determine the *date of earliest emergence* and not to indicate the absence or presence of the fly in any particular orchard. 88

Codling Moth

No insect causes greater loss to apple and pear growers in the Pacific Northwest than does the codling moth: Individual growers may lose more than 50% of the crop but by using proper control methods they could usually keep the losses below 5%. The codling moth is present in all of the apple growing districts of the west. It was accidentally introduced from Europe into the eastern states and then transmitted to the Pacific Coast.

The codling moth, with wings folded is about ⅛ inch in diameter and ½ inch long. The front or upper wings are brownish gray with lines of lighter gray and a bronze band at the tip. They have a wing spread of about ¾ inch. The moths live about 2 weeks only after they emerge from their cocoons.

The codling moth passes the winter as a worm in a cocoon, Fig. 8, about ¾ inch long. The cocoons are spun in cracks of bark, crevices and corners of boxes, sacks or packing sheds. The last brood of worms

Fig. 8. Codling Moth

to leave the fruit in the fall hibernate. In the spring the worms transform into pupae and emerge as moths about the time winesap apple trees are in bloom with the largest number flying in late May and early June.

The moths immediately start laying their eggs if the temperature is lower than 60 . The eggs are pearly white about pin head size and thin convex shape. The eggs laid in the cool weather require 12 to 14 days to hatch. In warm weather, 5 days. The first brood feeds upon the leaves. The second brood feeds upon the fruit entering the calyx end. 193

About 75% of the worms continue their development into pupae and emerge as moths in the current season. These are known as the second brood. The other 25% remain in the cocoons along with the late season worms that leave the fruit in the fall and become next year's first brood. This second brood usually appear as moths early in July. After this time, moths are in large numbers until the cool weather in September, which ends the moth's activity for the season. In the warm localities there is even a third generation.

Corn Borer

During its lifetime, the borer, Fig. 9, goes through four states of development: egg, worm, cocoon, and moth. An understanding of this insect and its habits will show why clean plowing and time planting are so important in preventing damage.

Adults of the southwestern corn borer are moths that are soiled white to pale yellow in color and about three-fifths to three-fourths inch long. They fly mostly at night and seldom are seen during the day. The small white eggs are deposited singly or in chains both on the upper surface and lower surface of the leaves. Borers (larvae) are dull white in color with a regular pattern of brown or black spots. However, upon maturing in late summer or early fall, second generation borers lose their spots and become entirely white. When full grown they are 1 to 1¼ inches long. The resting stage or pupae has a typical brown color and is found within the tunnel made by the borer.

Moths spend the daytime in fence rows, fields of small grain, and in like places. In the evening they fly into cornfields and lay most of their eggs just after sunset and just before sunrise. The eggs, deposited in masses of 15 to 25 on the underside of corn leaves, hatch in 5 to 7 days. The moths are very choosy about where they deposit these eggs. They select the tallest or most advanced corn in a neighborhood.

Worms from eggs laid by early-season moths survive better on taller, usually earlier, corn than on shorter, usually later, corn. This fact has been proven by research in Illinois and other states, especially Connecticut. If the corn is small when the eggs hatch, most of the worms will die. To live they must hatch out on fairly tall corn. They are most likely to live when they hatch on corn that is almost *ready to tassel.*

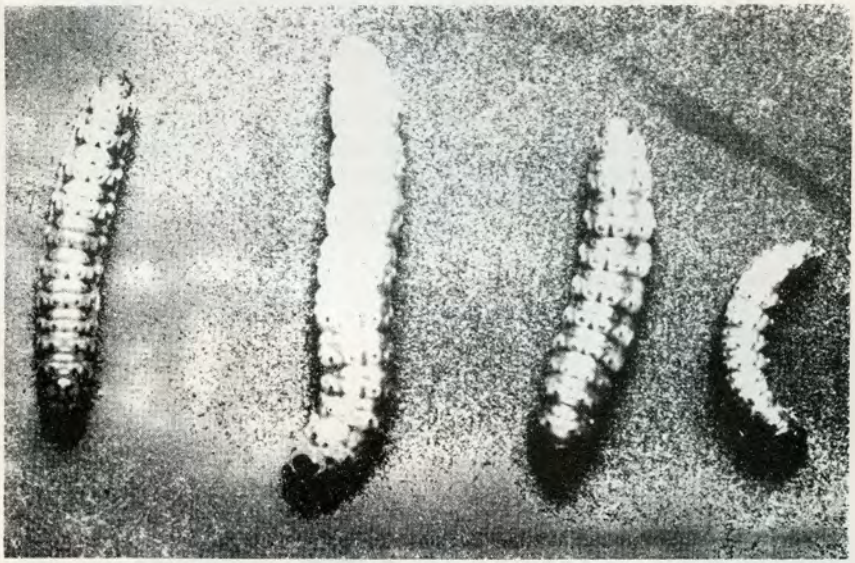


Fig. 9. Courtesy U. S. Department of Agriculture
European Corn Borer Larvae

Worms that hatch from eggs laid by early-season moths move to the curl of the plant and feed there. As the plant grows, they burrow into the stalk. At this time they often also feed in the midribs of the leaves. Their feeding on the leaves causes a good many leaves to break. Broken leaves stunt the plant and cut down yields, sometimes as much as 12 to 15 per cent. Boring also opens the way for entrance of plant diseases. The borers do not stay in one place but often crawl out on one burrow

DO NOT USE ANY DOSAGE RECOMMENDATION
WITHOUT FIRST VERIFYING IT WITH YOUR LOCAL
COUNTY AGENT WEED SPECIALIST
OR STATE ENTOMOLOGIST.

and make themselves another. During their lifetime as worms many borers make two burrows. Early-season worms when full grown are most often found near the base of the plant. 162

There are two generations or broods of borers per year. Mature borers or larvae of the second generation are present throughout the winter in the base of the stalks. Adult moths developing from these overwintering borers emerge during the latter half of June and deposit eggs on the young corn plants. Borers, hatched from these eggs, which are known as first generation borers deposit eggs for the second generation. These reach maturity by about mid-September.

Courtesy U. S. Dept. of Agriculture
Fig. 10. Corn borer infested cosmos

Corn Earworm — See tomato fruit worm.

Colorado Potato Beetle

Colorado potato beetle is perhaps the best known insect crop pest in North America. In 1824 it was known to occur only along the Rocky Mountains, where it fed on buffalo bur, or sand bur. One theory of its method of migrating to the eastern United States is that along the trails or roads made by the pioneers going west, the native vegetation was killed in long narrow strips and the bur weeds came in quickly and spread eastward. Thus the insects were able to cross the plains which originally were without a suitable host. In the potato plant, which is related to the bur weed, they discovered a more plentiful host and consequently multiplied in such numbers that for many years it was difficult to grow potatoes. The pest was found in Nebraska in 1859 and by 1874 had spread to the Atlantic Coast.

Until the potato beetle crossed the plains, practically nothing was known to control insects. About 1863 some green paint accidently splashed on some heavily infested potato vines and the bugs died. It was discovered that paris green, which had been used as coloring for the paint, had killed the potato bugs. For the next 30 years paris green and other crude arsenicals were the only stomach poisons available. Lead arsenate, developed in 1893, and calcium arsenate, in 1908, have largely

replaced paris green, which usually is very injurious to foliage. In 1889, arsenicals and fungicides were first used together on potatoes to control insects and diseases.

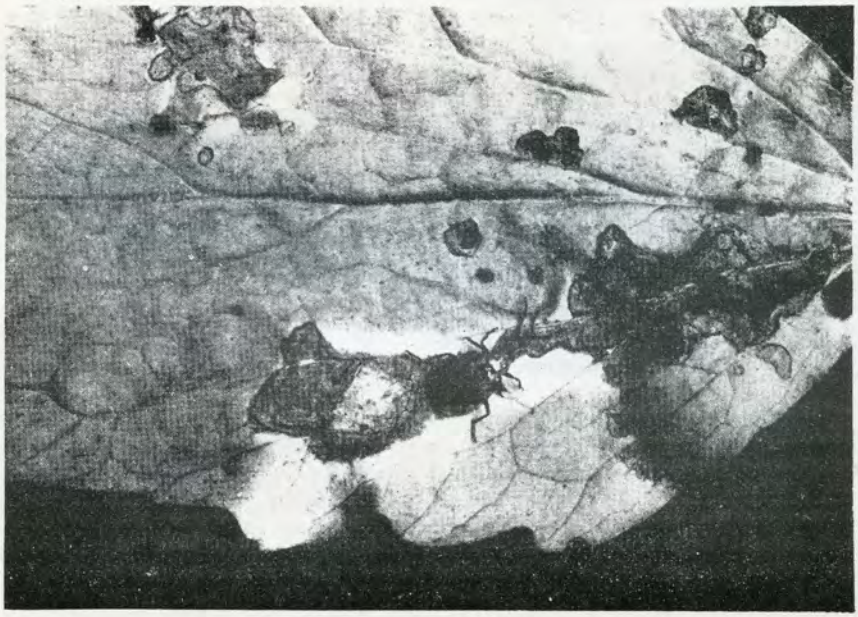
The adult, yellow-and-black-striped beetle, passes the winter buried several inches in the ground. Soon after the young vines appear the adults emerge and lay groups of yellow eggs on the underside of the leaves. The larvae are hump backed, reddish, with black dots on the side. Both adults and larvae are ravenous eaters and can rapidly destroy a potato patch.

Control may be obtained by the use of several insecticides, such as calcium arsenate, lead arsenate, cryolite, and rotenone. DDT is very effective and is to be preferred over the insecticides just listed. Either of these is compatible with potato fungicides. 202

Cucumber Beetle

Two beetles are always found on cantaloupes, cucumbers, watermelons, pumpkins and squash. The more important is the yellow-and-black-striped beetle; the other, known as the spotted cucumber beetle, see Fig. 11, is greenish-yellow, with 12 black spots. The later is also a pest of corn and is known also as the southern corn root worm.

Fig. 11. Courtesy U. S. Department of Agriculture
Spotted Cucumber Beetle



The adult of the striped cucumber beetle overwinter in protecting trash and make their appearance early in the spring. The beetles attack the leaves as they appear above the ground, and often work rapidly enough to destroy the entire plant. The larvae also live on the roots and tunnel the underground parts of the stems. The bacteria of cucumber and cantaloupe blight overwinter in and are are spread by this insect. 201

Injury is caused mainly by overwintering beetles gnawing and eating the stems of young plants. Bacterial wilt is also transmitted by these two cucumber beetles. The larva also damages roots of cucurbits. Cucumbers, cantaloupes, pumpkins, gourds, summer squash, and watermelons appear to be injured in about the order named.

Adults hibernate and enter fields early in spring just as seeds are germinating. They feed on plants, even selecting places free of arsenicals, and lay their yellowish eggs in the soil about the plants. The striped cucumber beetle worm develops on cucurbits but the spotted cucumber beetle also feeds on corn roots and is known as southern root worm on corn. The pupa is also found in the soil but the adults emerge and feed on other plants and may produce several generations. 204

As the name implies, flea beetles, Fig. 12, are very small, about one-sixteenth of an inch long. They jump like fleas. They are usually found on garden stuff, sugar beets, and potatoes where their feeding often results in defoliation. The adult of most of the flea beetle species spends the winter hidden under trash, cracks in the ground and other protected places. In the spring, eggs are laid by these over wintering adults usually in the soil about the plants. The larvae which hatch from the eggs feed on the roots of the plants underground until they pupate and emerge as adult flea beetles. Control applications are directed against the adult stage and should be applied as soon as damage is noted on leaf surfaces. This will usually be in the early summer.

Fig. 12. Adult striped flea beetle
Courtesy U. S. Dept. of Agriculture

The adult flea beetles injure the plants by eating holes in the leaves. See Fig. 13. In severe cases they may completely skeletonize the foliage. These insects usually do the most damage to young plants which may be stunted or killed when the leaves are eaten. The larvae may damage the roots or plants by feeding on them and some species feed on potato tubers, causing them to be rough and pitted. When this occurs the yield is generally reduced and the market value of potatoes is greatly lowered.

The eggs of the flea beetle are elongate-oval, light yellow in color and are so tiny that they would seldom be noticed. The larvae are quite small, slender, whitish in color except the head, which is brown. The pupae are naked with legs, eyes, antennae, and other parts distinguishable. They are small and white to light brown in color. The different kinds of adult flea beetles are quite similar in size and shape but vary in color. Those which do the most damage in Montana are elongate-oval, about ⅛ of an inch long, and shiny black in color. These insects are able to jump some distance.

The adult flea beetles pass the winter by hibernating under leaves and rubbish on the ground. They generally emerge in June or July and deposit their eggs in the ground around the roots of host plants. These eggs hatch in from one to two weeks and the larvae feed under the soil surface upon the roots of plants. The larvae stage lasts about a month, after which the larvae pupate. The adults emerge in about ten days. There is one generation a year and possibly a partial second brood. 120

Fig. 13. Courtesy U. S. Department of Agriculture
Flea Beetle Damage

Flies

● REPORT OF A FIELD INVESTIGATION OF FLY CONTROL: (Reprint No. 2901 Public Health Reports — courtesy United States Department of Public Health.)

Airplane application of insecticide is accomplished by flying a series of parallel swaths over the area. The effective swath width and rate

of application can be determined only when the cross section of insecticide recovery is known for a particular dispersal equipment.

The recovery of DDT across a swath section was determined by analyzing droplets collected on clean glass slides placed at 20-foot intervals at right angles to the line of flight. Eleven stations were studied for a distance of 100 feet to either side of the flight line. Winds as a factor on swath characteristics were minimized by conducting flight tests in the early morning hours after dawn. Procedures for obtaining the quantitative rate of surface recovery were similar to the methods used for the study of airplane exhaust generators as described by Kruse and Metcalf.

Solutions of DDT applied from aircraft kill flies when the flies come in direct contact with falling droplets and in contact with sprayed surfaces. The former is immediate in its action while the latter may provide a residual over a period of time. The relative efficiency of contact and residual action of the spray droplets was not completely investigated and should warrant future study. With the spray normally used an average of 49 droplets of insecticide was recovered per square inch of area.

For the lower rates of application, eight ¼ LN 12 cone-type atomizing spray nozzles were employed and for higher rates, eight 8004 flat-type spray nozzles were used. Both types of nozzles were manufactured by the Spraying Systems Company. The ¼ LN 12 nozzle is rated at 0.2 gpm. at 40 psi., while the 8004 nozzle delivers 0.4 gpm. at 40 psi.

Good recovery was obtained with the ¼ LN 12 at an application rate of 0.3 pound DDT per acre. The spray had a wide range of particles having a MMD of 160 microns and a mean of 115 microns. One-half of the droplets recovered were below 85 microns and were quite similar to the aerosol generated by the 4-inch exhaust stack.

The swath cross sections show that with the 8004 nozzle applying insecticide at 0.5 pound DDT per acre the spray provided a good recover, however, there is an increased number of large droplets. The spray had a MMD of 200 microns with a mean of 140 microns. One-half of the number of droplets recovered were less than 100 microns in diameter.

1. Experimental studies on aircraft spray equipment provide basic data upon which practical and effective fly control may be achieved rapidly in urban communities.

2. Fly control through the application of DDT solutions from aircraft is obtained jointly by mortality from direct contact with droplets and through residual toxicity on treated surfaces. The residual toxicity is of short duration and in view of many variables can not be depended upon to provide more than 25 per cent kill. Recoveries in excess of 0.1

pound of DDT per acre are required for satisfactory control with spray having median mass diameter (MMD) of from 160 to 200 microns.

3. Satisfactory fly control in urban situations without staining damage may be obtained with sprays having a MMD of 200 microns applied at heights of flight of from 100 to 150 feet. The desirable application rate is 0.5 pound DDT per acre (100 foot swath basis) using a solution of 30 per cent technical DDT in Velsicol AR-60. 209

● CONTROL OF FLIES IN URBAN AREAS: Airplane equipment seems to be ideally suited for bringing about temporary fly control rapidly and effectively in urban areas during time of emergency such as epidemics, catastrophe, or war. The practicability of emergency fly control in urban areas was demonstrated by Quinby, Coffey, and McNeel in northern Alabama in 1946.

Important departures from standard aircraft insecticidal techniques are required in urban fly control.. Normally, insecticidal applications are made at a height of 20 to 30 feet during inversion conditions existing just after dawn. When applying insecticides over buildings of a community, or in steep hilly terrain, flight altitudes much below 100 feet are prevented. The average height is 150 feet. For most effective urban control, the insecticides should be applied when the flies are most active, which is late in the morning after winds and unstable air conditions have developed. Special consideration must be given to the selection of insecticides and solvents in order to minimize the staining effect of the droplets on laundry, automobiles, and other community property. 209

Methoxychlor is now recommended for use in dairy barns against flies, 125 to take the place of DDT now banned by the Food and Drug Administration for use in dairy barns.

● HOUSE FLIES DEVELOP RESISTANCE TO DDT: House flies in some areas have developed a marked resistance to DDT. During the summer of 1948 reports of the failure of this insecticide to provide the usual high degree of fly control were received from many parts of the United States. Investigations showed that improper application of DDT and failure to prevent excessive fly breeding were important factors responsible for these failures. However, tests with flies collected from certain areas in Florida, Georgia, Texas and California show some of them to be 20 to 50 times as resistant as nonresident laboratory strains.

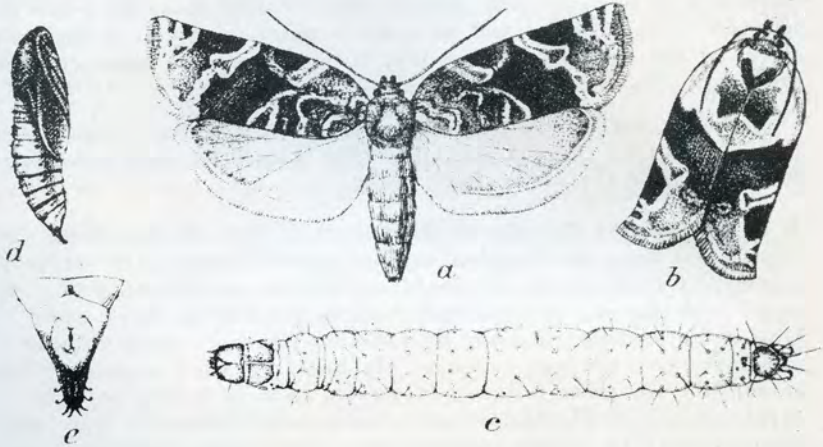
That house flies can develop resistance to the point of practical immunity has been demonstrated in laboratory experiments. Sucessive generations of flies that survived exposure to DDT were reared until a strain was developed that was about 250 times as resistant as nonresistant strains. This selection required 3 years and 60 generations, in each of which about 90 per cent of the flies were killed by increasing dosage or exposures.

In view of the marked resistance of some fly strains to DDT, several possible substitute insecticides were investigated. Methoxychlor, chlordane and gamma benzene hexachloride all showed promise, although certain strains of flies highly resisant to DDT also showed some resistance to these insecticides. 271

Fruit Tree Leaf Roller

The adult leaf roller is a cinnamon brown moth with two or three light yellow markings on the wings. See Fig. 14. It is a little larger than the codling moth. Each female normally lays all her eggs in a single mass on the limbs, twigs, and trunk in June or July, where they remain over the winter. As the buds begin to open, the eggs hatch and the small active caterpillars feed upon the unfolding leaves, webbing them together and forming a protection for themselves. As the larvae mature, they bind together the larger leaves forming a nest-like structure. They feed within this structure, defoliating the leaves and eating holes into fruit. There is one generation per year. They attack apples as well as stone fruits. 58

Fig. 14. Courtesy U. S. Department of Agriculture
Red Banded Leaf Roller



Grape Leaf Folder

The grape leaf folder is a pale green worm about 1 inch long. It folds over the grape leaves to form a roll about the size of a lead pencil. There are two generations each year. The second brood of worms usually does the damage. 60

Grasshoppers

Every state within the regions subject to outbreaks of the common grasshopper, contains at least a hundred different species. See Fig. 15. Some are very rare, others fairly common, and a very few that occasionally become abundant enough to injure crops. According to the United States Department of Agriculture at least 90 per cent of all grasshopper damage to cultivated crops in the United States is caused by a small group of five species. These are the migratory grasshopper, the differential grasshopper, the two-striped grasshopper, the red-legged grasshopper and the clear-winged grasshopper. 132

Grasshoppers fall into two main groups — the r a n g e grasshopper which migrates freely and the crop grasshopper which tends to stay localized in crop areas.

Fig. 15. Courtesy U. S. Department of Agriculture
Grasshopper

● MIGRATORY GRASSHOPPER: The migratory grasshopper is reddish brown, with an irregular black patch on the neck or collar and is about 1 inch in length. Although comparatively small, it is a strong flier and sometimes gathers in great swarms which migrate long distances, injuring crops wherever they pause in their flight. It is found throughout the United S t a t e s, but is most abundant in the northern Great Plains and the Rocky Mountain and Plateau States. It prefers well-drained, light soil and sparse vegetation for its breeding ground. The migratory grasshopper is similar in most respects to the Rocky Mountain locust, or grasshopper, which ravaged Western States years ago. 132

● DIFFERENTIAL GRASSHOPPER: The differential grasshopper is yellow, with contrasting black markings and clear, glassy hind wings. The hind wings bear distinctive black bars arranged like chevrons. It is a large grasshopper, nearly 1½ inches in length. Ordinarily it is a weak flier but, when extremely abundant, sometimes becomes migratory in habit and may fly long distances. It is seldom found farther north than the southern counties of North Dakota and Minnesota. It is found from the Atlantic to the Pacific Coast but is most injurious

in the Great Plains, upper Mississippi Valley, and Southern States. It prefers heavy soil for egg laying, and rank-growing vegetation for food, being particularly fond of corn and soybeans. 132

● TWO STRIPED GRASSHOPPER: The two-striped grasshopper gets its name from the two conspicuous light colored stripes which run the length of its back from the head to the wing tips. The general body color is greenish yellow, with contrasting black or brown markings and colorless wings. It is sligtly smaller than the differential grasshopper, but larger than the migratory grasshopper, measuring about $1\frac{1}{4}$ inches in length. It is found from Southern Canada to Mexico, except in the South Atlantic States. It prefers heavy soils and succulent vegetation. 132

● THE RED-LEGGED GRASSHOPPER: The red-legged grasshopper is reddish brown above and yellow beneath. Its hind legs are usually tinged with bright red, and its wings are colorless. It is smaller than the migratory grasshopper and about three-fourths of an inch long. It occurs throughout the United States. It prefers low, moist ground. Alfalfa is a favorite food plant. 132

● CLEAR-WINGED GRASSHOPPER: The clear-winged grasshopper is about the same size as the migratory grasshopper, measuring about 1 inch in length. Its color ranges from yellow to brown. The under wings are clear, but the front, or outer wings, are blotched with large brown spots. It occurs in all the Northern States that border Canada from the Atlantic to the Pacific, but is seldom found in more Southern States. Its favorite habitats are mountain meadows, pastures, and roadsides. It is primarily a grass feeder, but when present in outbreak numbers is very destructive to small grains. It is migratory in habit, both in the immature and adult stages. In some States it is called the warrior grasshopper, because the young grasshoppers frequently march in bands from one field to another. 132

HISTORY OF GRASSHOPPERS IN THE U. S.

During the period of 1874 to 1877 the Rocky Mountain grasshopper, or locust as it was then called, increased to such numbers that its depredations were considered a national calamity. Great swarms originating in the plains east of and adjacent to the Rocky Mountains in Montana, Wyoming, and Colorado migrated eastward to the Mississippi Valley and southward to Texas, devouring crops wherever they paused in their flights. Damage to crops amounted to $200,000,000.

Congress recognized the seriousness of the outbreak and on March 3, 1877, created the United States Entomological Commission and authorized it to investigate the grasshopper problem. This organization,

headed by C. V. Riley, developed into the Division of Entomology of the United States Department of Agriculture, which has now become the Bureau of Entomology and Plant Quarantine.

For some time it was believed that grasshoppers would become less abundant as the Western States became more thickly settled and more land was brought under cultivation. It now appears that the present large acreages of crops and idle land, added to the natural breeding grounds, offer grasshoppers a greater, more varied, and more succulent food supply than did the native grasses and that conditions are now more favorable for their development than before the land was disturbed by man. Grasshopper control must therefore be recognized as a permanent problem which should include not only killing the grasshoppers after they become dangerous numerically, but also the adoption of such tillage and seeding methods and other farm practices as are known to check grasshopper increases. 132

Grasshopper Control

Grasshopper egg beds are quite often concentrated in marginal areas around cultivated crops. In the spring the small 'hopper (nymphs) of most species will be found concentrated around the edges of the fields, along ditch banks, roadsides, fence rows, etc. Only on rare occasions will the very young 'hoppers be found out in the fields to any appreciable extent. The lesser migratory locust is the main exception, and very young 'hoppers of this species are commonly found in cereal fields. Obviously, the young 'hoppers can be controlled much more economically in these marginal concentrations before they have moved into the fields. Sprays applied for grasshopper control seldom give satisfactory results when used on *dry* or *mature* foliage. They are most reliable on lush, green foliage. Therefore, spraying should be terminated when the crops begin to dry up or mature. This should be carefully considered, particularly on cereal crops such as wheat, barley, oats, rye, etc.

Apply either one and one-half pounds of toxaphene per acre or one pound of chlordane per acre. Recommendations can be found for lower rates of application per acre; however, it is felt that these lower rates of application are not satisfactory under Montana conditions. The chlordane or toxaphene can be satisfactorily applied in either one gallon of oil solution per acre or two gallons of water emulsion per acre.

The following precaution is quoted from a bulletin published by the Bureau of Entomology and Plant Quarantine, Agricultural Research Administration, United States Department of Agriculture, No. EC-7, entitled "Grasshopper Control Improved by New Insecticides", dated February, 1949.

> "Precaution: Do not feed forage treated with these new insecticides to dairy animals or to animals being finished for slaughter.

Some of these insecticides are known to accumulate in the fatty tissues of animals and are given off in the milk and butter fat. Forage treated with them at dosages heavier than needed for grasshopper control has been fed to meat animals continuously for several weeks to the exclusion of all other feed, without visible impairment to their health or development. However, meat animals feeding for long periods on treated forage may accumulate enough of these chemicals in their tissues to make the meat unfit for food. This possibility is greatly reduced if no treated vegetation is fed during the last two months before slaughter."

● RANGE GRASSHOPPER CONTROL: It has been demonstrated that many range grasshoppers can be effectively controlled before they reach the adult stage (before acquiring fully developed wings) with chlordane or toxaphene dry bran bait. The dry bran bait should be applied at the rate of five pounds per acre in the case of light infestations, seven and one-half pounds per acre in the case of medium infestations, and ten pounds per acre in the case of heavy infestations. If in doubt, it will probably be best to use from seven and one-half to ten pounds of dry bran bait per acre.

Cattle have been killed where they have had access to this bait. Mortality in cattle has resulted where grazing was allowed on airstrips that have been improperly cleaned up after the operation. Be certain that cattle are not allowed access to this bait, and be sure that the bait is completely cleaned up in operational areas. It is hoped that more information will be available on this subject before the 1950 control season. [120]

Recent investigations by federal entomologists indicate that chlordane is most effective for grasshopper control when applied to succulent vegetation where the insects are feeding in large numbers. According to J. R. Parker and Claude Wakeland, Bureau of Entomology anl Plant Quarantine, spraying or dusting succulent growth along roadsides, railroad rights-of-way, canal banks, and field margins kills grasshoppers more rapidly than when baits are applied. This results in better control. "On bare ground, dry stubble, or in tall, dry vegetation which is no longer attractive to grasshoppers as food, bait is generally more effective and economical." [105]

Toxaphene is a chlorinated product of the turpentine industry. This organic insecticide has been found particularly useful against grass-

hoppers and plant bugs. The trend is rapidly toward the use of insecticides rather than bait in grasshopper control. When green foliage is available wet baits are least reliable. Later in the season when the foliage becomes dry and scarce the sprays are less effective and the wet baits become more effective.

Grasshoppers tend to bunch up in hatching and feeding areas. Usually along the margins, fence rows and ditch banks. In the early spring these areas should be sprayed with toxaphene or chlordane. Toxaphene and chlordane may be used in combination with DDT except on alfalfa or clover which is to be used for stock feed. When foliage is to be used for stock, tepp (which acts as a contact spray) can be used in its place.

● USE OF ALDRIN GRASSHOPPERS IN MONTANA: Extensive use of aldrin was made in Montana and Arizona on grasshopper control. On the basis of favorable results obtained the United States Department of Agriculture has approved the use of aldrin on forage and cereal crops. Aldrin should not be used on forage or pasture used for dairy cows or cows being fattened for market until at least 21 days have elapsed after treatment. Application rates of as low as ⅛ pound per acre are reported to have given almost complete control.

The following is a resume of a report taken from "Bugs" published by the office of the Montana State Entomologist, December 1, 1950. "Air-applicator No. 1 sprayed 21,000 acres of range, fence rows, roadsides, winter wheat, barley, oats, rye, and rape with 1½ to 3 ounces of aldrin in ½ to 1 gallon of oil per acre. Results were reported good with the exception of a few cases where source of immediate reinfestation was present. In this operation 420 gallons of 60% aldrin was handled with no ill effects on man. On several occasions the flagmen were sprayed. Some reported nausea. Pastures containing cattle were sprayed with no ill effects. This report is typical — none reported unfavorable results or ill effects on either cattle or man."

Summarizing the use of aldrin in Montana, the editor of "Bugs", Mr. J. P. "Cork" Corkins, states that a total of 56,000 acres were reported on which used 1185 gallons of aldrin. Results were good to excellent with dosages of 1½ to 3 ounces per acre in ½ to 1 gallon of oil. Crops ranged from succulent to mature. Although cases of nausea and headaches were reported, none were serious.

The Montana Office of Entomology recommends that (1) rubber gloves be used when handling liquid aldrin, (2) avoidance of inhalation of fumes, (3) use of soap and water to wash off aldrin spilled or splashed on skin, (4) use care to avoid spilling aldrin. Although there appears to be no danger to livestock where dosages up to 2 ounces per acre are used, this is not yet proven. Similarly, until the cumulative effects of aldrin are known every precaution should be used to keep it off the skin and avoid inhaling or injesting it.

● CONTROL OF GRASSHOPPERS WITH WET BAIT: Chlordane or toxaphene in the form of emulsion concentrates or wettable powders can be substituted for sodium fluosilicate in any wet-bait formula containing bran and sawdust. Either one kills more quickly and for a longer period than sodium fluosilicate. Chlordane at ½ pound and toxaphene at 1 pound have consistently given at least as good kill as 6 pounds of sodium fluosilicate per 100 pounds of dry bran and sawdust.

Stir the emulsion concentrate or wettable powder into the quantity of water required for wet baits and apply to the bran-sawdust mixture in a single mixing operation. They are obtainable at various strengths, but, whatever their strength, use enough to provide the amount of insecticide indicated in the following formula:

Mill-run bran	25 pounds
Sawdust, three times the volume of bran	3½ bushels
Chlordane	½ pound
or	
Toxaphene	1 pound
or	
Sodium fluosilicate	6 pounds
Water to make a moist, crumbly mash	10 - 12 gals.

Spread wet bait uniformly at the rate of 20 pounds per acre.

● CONTROL OF GRASSHOPPERS WITH DRY BAIT: Dry baits made by impregnating coarse bran with an oil solution of chlordane or toxaphene have been used very successfully in controlling grasshoppers on range land. Use ½ pound of chlordane or 1 pound toxaphene in each ½ gallon of solution. Kerosene and fuel oil have been used as solvents. Apply the oil solution as a finely divided spray at the rate of ½ gallon to 100 pounds of coarse, dry bran containing no flour-like material. Power bait-mixing machines may be equipped with spraying devices for this purpose. In mixing dry bait every effort should be made to obtain uniform distribution of the small quantity of solution throughout the dry bran.

Dry bait can be applied by airplane and single-outlet dusters, but wet bait broadcasting machines are not equipped to apply such a small quantity uniformly. The dosage recommended, 5 to 10 pounds of dry bait per acre, is equivalent to 20 to 40 pounds of wet bait in terms of bran content. This is an advantage, particularly when bait is applied by airplane, because the plane can operate four times as long without reloading. Dry bait may be prepared in advance and stored until needed.

Greenbug

Wheat aphids or *greenbugs* suck the juices from the leaves often killing the plants. They are also suspected of transmitting mosaic. Greenbugs appear in the early spring months. 152 (see aphis)

The beetles are a little less than half an inch long, and a shiny, metallic green, with coppery-brown wings. You can tell them by the six small patches of white hairs along each side and the back of the body, just under the edges of the wings.

Japanese Beetle

The beetles first appear on their favorite food plants early in the summer. In parts of Virginia they begin to come out about June 1, in the vicinity of Philadelphia about June 15 and in New England about July 1 or later. Their numbers increase steadily for several weeks, and the period of greatest beetle activity lasts from 4 to 6 weeks. Then they gradually disappear. In Tidewater, Virginia, most of the beetles are usually gone by the early part of August; in New England they may be fairly numerous until frost.

Japanese beetles fly only in daytime. They are especially active on warm, sunny days. They feed on the parts of plants or trees exposed to the sun. When feeding on leaves they chew out parts between the veins, giving a lacelike appearance to what is left. Injured leaves soon drop. A badly attacked tree or shrub may lose most of its leaves in a short time. A list of many of the more important plants, shrubs, and trees, classified according to whether or not they are subject to feeding is given on pages 4 and 5

The beetles are especially fond of ripening fruits. They often mass upon such fruits and feed until nothing edible is left. They do not usually touch unripe fruit. The beetles injure corn seriously by eating the silk as fast as it grows, and keeping the kernels from forming.

Leafhopper

The beet leafhopper is the spreader of *curly top*. Curly top is a virus disease causing severe injury to many crops, particularly those grown in the irrigated areas of the Rocky Mountain and Pacific Coast states. Curly top causes large losses each year to crops in central Washington. It produces some losses in eastern Washington, and a few losses occur west of the Cascades. This disease was first found on sugar beets, and the name curly top applied because of its effect on beets. The same disease is now known to attack many other kinds of cultivated and non-cultivated plants. Many common names have been used, the meaning of which cannot be combined into a single name. We are using the name curly top for the diseases caused by the same virus on all crops.

The curly-top virus, like many other virus infecting plants and animals, has an insect carrier. This insect is the beet leafhopper. It was first identified on beets and is native to sagebrush areas and former range lands of the west. The leafhopper also lives on mustard, Russian thistle, filaree, and many other weeds and grazing plants. Large numbers of the leafhopper develop on plants and weeds that spring up following burning or overgrazing and on plants that are common to deserted farm lands.

The beet leafhopper is a migrating insect. See Fig. 16. It leaves its natural breeding grounds when the spring vegetation dries and moves with the prevailing wind. If the wind is strong and continues in the same direction for several days, large numbers of the leafhoppers may travel great distances.

Fig. 16. Beet leaf hopper

The young hoppers of the spring brood pick up the virus from the wild plants, and the virus is carried to cultivated crops when spring and summer migrations take place. Long periods of spring showers help the growth of host plants, making it possible for large spring broods of the leafhopper to develop. 61

Lygus Bug

Alfalfa for seed production can be treated in the bud stage for lygus bug control. The lygus bug feeds by sucking the juices from the plants. If they feed on the buds they cause the blossoms to "blast" thereby reducing the seed yield. The lygus bug is about ¼ inch long when full grown, greenish-tan to brown in color. The immature nymphs are bright green in color and resemble aphids somewhat except they are more active. 152

Mexican Bean Beetle

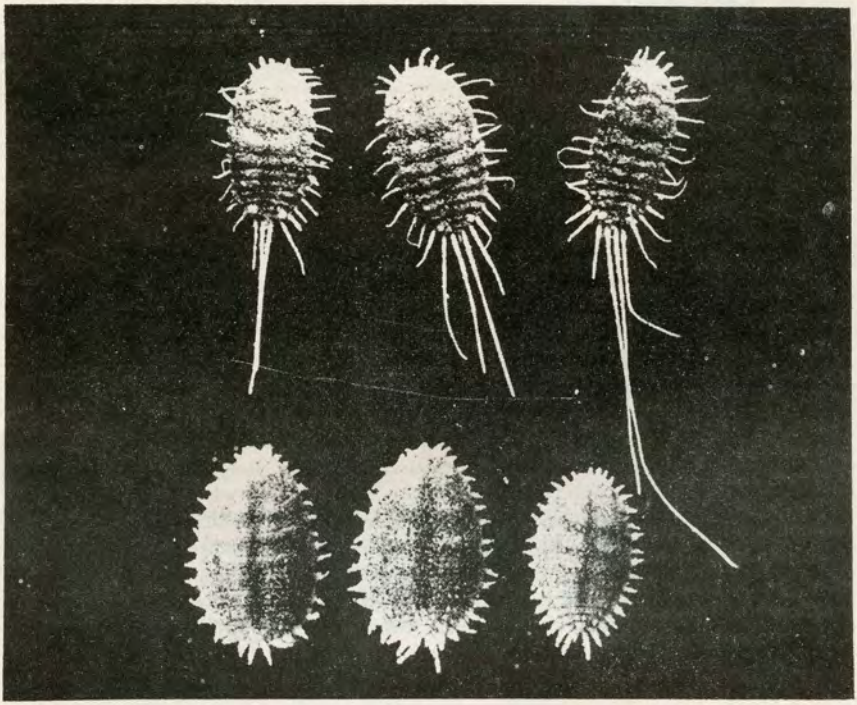
The adult Mexican bean beetle hibernates through the winter under protective cover. The first beetles emerge from hibernation in early June. At this time eggs are laid in clusters, on the bean leaves, usually on the lower surfaces. The eggs are about 1/20 inch long and yellow to orange in color. The hatching period is from 5 to 14 days. The larvae are yellow, 1/3 inch long when full grown, and covered with yellow spines. They feed for a period of two weeks or more, skeletonizing the leaves, and in some cases they attack both stems and pods. At the end of the larval feeding period they pupate for about 10 days and new adult beetles then appear. There may be two or more generations during a season. 152

Mealybugs

There are many species of mealybugs, Fig. 17. Mealybugs are only about 1/5 inch long when full grown. They derive their name from the fact that their oval or elongate bodies are covered with a white, waxy, or mealy excretion. This covering is pecularly protective against spray materials. The young, or nymphs, are much like the adults except that they are smaller and lack the mealy covering. The males develop into small, winged, midget-like adults, but are rarely seen.

With their sucking mouth parts they remove the vital plant juices, causing a loss of color, wilting, and death of the affected parts, if they are not controlled. Moreover, mealybugs excrete copious quantities of sticky honeydew, which may coat the foliage. 61

Fig. 17. Mealybug. Courtesy U. S. Department of Agriculture.



Mites

Mites are often serious pests of apples, particularly since DDT is used for codling moth. Mites are small plant-eating spiders, see Fig. 18, and not true insects. Two species have been observed, the European red

mite and the two-spotted spider mite. When abundant they cause a bronzing of apple foliate. They feed on the sap of cells, which they break open with their rasping mouth parts. At each feeding place the cell is killed and takes on a bronze color. Heavy bronzing is followed by defoliation.

If mites appear in larger number than 6 per leaf, they should be sprayed at least twice with either DN 111, dimite, or tetraethyl pyrophosphate, at about 10 day intervals. Recent work shows that another new chemical p-chlorphenyl p-clorobenbenesulfonate, released by Dow Chemical Company, is very effective. It acts as an ovicide and can be applied with alkaline fungicides. DDT should be replaced by lead arsenate to encourage natural control. The European red mite can be kept down, or at least retarded, by the annual 3% oil-emulsion dormant spray if care is taken to spray the main trunk and large limbs as well as the rest of the tree. The oil kills the overwintering mite eggs. The other species is not affected by winter sprays. 201

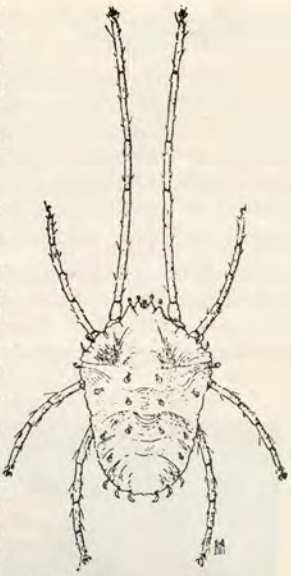


Fig. 18.
Clover or Almond Mite

● SPIDER MITES: There are more than 26 different kinds of spider mites such as the brown mite, almond or clover mite, barley mite, jumping mite, California citrus mite, pale mite, two spotted mite, six spotted mite and the common red spider. These minute animals are not really insects, but are relatives of the spiders. Their injury to plants, however, is similar to that caused by sucking insects. Spider mites feed by sucking juices from the leaves and other tender plant tissue. Their attack causes paling or browning of the foliage, which on close examination resembles stippling. Sometimes the infested parts of the plant are covered with fine webbing and in heavy infestations the mites can be found gathering in swarms on the under sides of leaves or running over the webbing which they spin. If the infestation is light there may be little or no webbing, and some species do not spin a web. The individual mites are so small that they can scarcely be seen with the naked eye. Although the living mites are not always found on injured plant specimens, their whitish shed skins and globular eggs or eggshells are usually present and visible under a lens. 61

● MITES ON STONE FRUITS: There are several species of mites which affect stone fruit trees. The most important of these are the European red mite, the Pacific mite, the two-spotted mite, the clover mite, the silver peach mite, and several species of rust mites.

The European red mite overwinters on the trees in the egg stage, and a thorough dormant oil spray is effective in reducing infestations. The

brown or clover mite overwinters as an egg or adult. A dormant oil or a delayed dormant lime-sulfur spray is effective.

The Pacific and two-spotted mites overwinter under bark or in trash in the orchard. They become active in the spring and move up into the trees when the foliage comes out. Therefore, control during the dormant season is not effective against these two species. Rust mites and silver peach mites overwinter under bud scale and feed on foliage during the spring and summer. These mites can be controlled with 3 per cent lime-sulfur plus 1 per cent dormant oil as a delayed dormant application. 58

● CLOVER OR ALMOND MITE: The clover mite, Fig. 18, attacks a large number of plants, a few of which are alfalfa, clover, peas, apple, peach and other stoney fruits, raspberries, many forest trees, and herbaceous plants. It may also enter houses and cause considerable annoyance. In dry seasons clover mites may damage trees and shrubs by sucking the sap from the buds and leaves. As a house pest they do no particular damage, but their habit of crawling all over the house, into food, and sleeping quarters is very annoying. Clover mites occur over most of northern United States and Canada. In Montana they have been found to be most common in the western part of the state.

The eggs are very small, spherical in shape and are a deep red color. The young resemble the adults with the exception that they are greenish color and smaller. The adult clover mites are smaller than the head of a pin. The body appears to be almost round and is a deep red color. Eight legs are present, with the front parts much longer than the others. The clover mites lay their eggs in the fall on the bark, branches and twigs of host plants, often in such large numbers that the twigs and branches have a reddish appearance. The eggs hatch in the spring and the young start to feed on the foliage. There may be two or three generations a year.

● RED SPIDER MITES: Red spiders also commonly known as spinning mites or spider mites, are, contrary to their common name, often green, brown or yellow in color. They are usually round or nearly round in outline, very small and have eight legs when fully grown. When viewed with a magnifying glass the body appears to be thinly clothed with long rigid hairs.

Red spiders often attack and cause damage to alfalfa, apple, beans, blackberry, chrysanthemum, cucumber, currants, eggplants, elm, lettuce, peach, pear, pepper, raspberry, rose, strawberry, tomato and many evergreens. A large number of other plants are frequently infested. Red spiders damage plants by sucking the plant juices from the leaves.

Heavy infestation cause a lightening or yellowing of the leaves of infested plants. In woody plants defoliation follows the characteristic

leaf yellowing, whereas herbaceous plants soon wilt down and die. The spiders spin very fine irregular webs over the leaves and stems of plants giving them a "cobwebby", unsightly appearance.

Adult mites hibernate during the winter and begin laying their eggs in the hot, dry weather of early summer. Eggs are laid on the leaves of plants and hatch in three to five days. The young mites which are quite similar to the adults in appearance require about 10 days in hot, dry weather to mature. The characteristic webs afford protection from wind and rain to the eggs and young mites. Several generations are produced out of doors in the summer and the mites will live and breed the year around in greenhouses or on house plants.

Mosquitoes

The new insecticides developed during the war have stimulated mosquito control to a greater extent than ever before. DDT was widely used by our armed forces during the war, and immediately thereafter mosquito-control districts began to use this new insecticide in various parts of the country with considerable success.

● MOSQUITO CONTROL *(Oregon suggestions — courtesy Oregon State College)*: There are 100 or more species of mosquitoes. The species vary greatly in their requirement and habits but they all have one common characteristic namely, they breed in water only. All have 4 stages: Adults, eggs, larvae, and pupae.

Mosquitoes are likely to be found abundant in:

(a) Overflow areas of rivers or irrigation projects.

(b) Tidal flats along the coast.

(c) Snow water in mountain areas.

(d) Woodland pools in the mountains.

(e) Irrigated lands.

(f) Semi-permanent and permanent ponds.

(g) Borders of sluggish streams and ditches.

Weather, including winter snowfall, and irrigation practices are greatly increased. Excessive winter snowfall in the high mountains not only produces more mountain mosquitoes but results in increased run-off and flooded areas in the river watersheds.

The irrigation of large areas in the state has created ideal breeding conditions for mosquitoes. Improper use of water, over-irrigation, and poor drainage enhance these conditions. The irrigation of uneven pastures with excess water and the run-off accumulations in low areas and roadside ditches aid in the production of large numbers.

Mosquitoes are controlled most economically and easily by destroying the larvae. This is done by spraying DDT on water areas where larvae are present. Satisfactory control usually requires community action. All residents of a town or a group of farmers in a rural area may be called upon to participate in and assist in financing a control program. Community action is important because mosquitoes may fly into treated areas from nearby untreated breeding places. Neighborly action can do much to reduce mosquito trouble. 197

● MOSQUITOES A RURAL AS WELL AS CITY PROBLEM: The mosquito problem in many areas is largely rural and agricultural in character. Mosquitoes affect the farmer, his family, his employees and his livestock. They cause important financial loss to the stockman, dairyman, and general farmer. Mosquitoes are blood suckers and cause loss of weight and reduce the milk flow of livestock. They often drive livestock from lush pastures to barren hillsides and thus further reduce flesh gains. Mosquito annoyance to agricultural workers results in loss of time and efficiency. 197

● USE OF EMULSIONS IN MOSQUITO CONTROL: *Emulsions*— DDT emulsion concentrates contain DDT, an organic solvent, and an emulsifier. The concentrate is diluted with water to obtain the desired strength of DDT for application. Many emulsion concentrates are commercially available, including the useful war-developed mixture composed of 25 per cent of DDT, 65 per cent xylene, and 10 per cent of triton X-100 (an aralkyl polyether alcohol). 197Z

● USE OF WETTABLE POWDERS IN MOSQUITO CONTROL: *Wettable Powders*—Wettable powders consist of finely ground DDT plus an inert carrier, such as talc, to which a wetting agent has been added. When mixed with water, the material can be sprayed, but constant agitation is required. Wettable powders are not generally used for larval control because of the difficulties of applying the mixtures from airplanes or with hand equipment. They can, however, be used in orchard-type power sprayers having an agitator. 197

● USE OF AIRPLANES IN MOSQUITO CONTROL: For mosquito control over large areas the airplane is both effective and economical. Excellent results have been obtained over extensive flood-water lands along the Columbia River and in large irrigated sections, particularly in California. Commercial operators can generally be relied upon to do a good job.

The airplane can be used to disperse DDT for control of adult mosquitoes as well as destroying the larvae. Many large-scale operations are directed primarily at destruction of the adults. Airplanes equipped with either the boom dispersing system or the exhaust generator can be used although the last-mentioned advice is not effective in winds of 10 or more miles per hour. A dosage of 0.2 to 0.4 pound of DDT per acre should give good results. 197

● MOSQUITO CONTROL (MONTANA RECOMMENDATIONS): A mosquito control program can only be effective when measures are included to eliminate breeding areas and recurrence of infestations. Before spraying is begun, a thorough survey of a radius of about three miles around the area to be protected must be made and all breeding places accurately mapped. All standing or quiet water within this area should be thoroughly sampled for mosquito larvae since larvae will often be concentrated in large numbers within a small portion of the total water area. These breeding places should, wherever possible, be eliminated by draining or filling them in. Any standing water, including that in tin cans, rubber tires, etc., may serve as a potential breeding place for mosquitoes, and therefore should be eliminated. After taking these preventative measures, the areas in which mosquitoes are actively breeding should be thoroughly sprayed with a DDT oil solution. If the control program is set up to produce a long residual effect, two or even three pounds of DDT per acre dissolved in oil may be required. If only an initial kill (short period control) of the larvae is desired, one-fifth to one-half pounds of DDT per acre may be effective. It should be kept in mind that in some situations the higher DDT doseage (one to two pounds per acre) may be hazardous to fish and other wild life.

There are many variable factors involved in a mosquito control program, such as species of mosquito, density of vegetation covering the surface, stage of the mosquito (adult or larva), type of kill desired (residual or initial) and type of water. Because of these variable factors, a determination of the approximate minimum effective dosage of DDT in a particular area should be made by preliminary tests before starting large scale airplane spraying.

Where vegetation is not too dense, and only adult mosquito control is desired, one to two quarts of 5 per cent DDT solution per acre is recommended. Under ordinary conditions, this treatment will remain effective for approximately two weeks. It may be necessary to repeat these spraying at regular intervals throughout the season when cities or towns are located near particularly bad mosquito breeding areas. 120

The United States Department of Agriculture Bureau of Entomology in its 1949 report has this to say about the control of mosquitoes with DDT: Aerial application of DDT gave excellent control of mosquitoes and black flies. In Alaska several areas comprising up to 30,000 acres were treated at the rate of 0.1 pound of DDT per acre. Both larvae and

adults of *Aedes and Culiseta* mosquitoes were killed. Mosquitoes in Alaska are unusually strong fliers, however, and several sprayings during the season were necessary to give protection against those flying in from untreated areas. Black fly larvae in streams were also killed by this treatment. A single passage of a C-47 airplane spraying an 800-foot swath across a stream gave complete control of these larvae for a distance of 2½ miles below the place of application.

Experiments were continued with applications of DDT to mosquito-breeding places before snowfall. In Oregon good control of mosquitoes was obtained with 0.5 pound of DDT applied at this time. In Arctic areas treatments before snowfall and applications to the snow killed larvae hatching in the spring, but results were erratic when dosages less than 0.25 to 0.5 pound per acre were used. In comparative tests more dependable control at lower dosage was obtained when applications were made after the eggs had hatched. However, repeated applications of DDT against adults over mosquito-breeding areas left sufficient deposit to cause a marked reduction of larvae the following season. Observations in Pennsylvannia after aerial spraying with DDT for gypsy moth control showed that black flies were killed by the treatment. 271

Oriental Fruit Moth

The oriental fruit moth larva is pinkish-white with a black or brown head resembling the codling moth larva but somewhat smaller. A few oriental fruit moth specimens have been found in Oregon and this pest is being watched closely. 101

The first adults were found in Washington several years ago, but no commercial injury was seen until 1948 when a limited area in the lower Yakima Valley was discovered. Observations in 1949 indicate that the moth is more widely distributed than originally thought. The life history and appearance of the insect is similar to that of the codling moth.

The insect overwinters as a grayish white larva in cocoons under the bark of infested trees or in other sheltered places. The small gray-brown moths emerge about two weeks earlier than the codling moth, or about the first week in April. The eggs are laid on the leaves and twigs and the emerging larvae bore into new growth or terminals causing them to wilt and flag. This injury is identical to that caused by the twig borer. The two larvae can be distinguished, however, since the oriental fruit moth larva is entirely *grayish white* while the twig borer is brown. Later broods enter the fruit in large numbers. There are probably five broods per year in the lower Yakima Valley.

Any *grayish white or cream-colored* caterpillar found boring in the smaller twigs or in fruit such as peaches may be the oriental fruit moth. *Watch for it.* Primarily a peach pest, it also attacks most other stone fruits as well as apples, pears, and quinces.

Orange Tortrix

The larvae of the orange tortrix are yellowish green "worms" with brown heads. The larvae are one-sixteenth of an inch long at the time of hatching and are an inch long when full grown. The larvae feed in the new tender terminal leaf growth on their host plants where they web the leaves slightly together. When the berries ripen, some of the worms leave the terminal shoots and enter the base of the berries to feed on the inside of the fruit. They have been found in fruit of blackberries, Boysens, Logans and Youngberries, but have not been observed in raspberry fruits in fields.

As the pickers deposit raspberries in their picking baskets, the larvae are disturbed and drop from the leaves on a strand of silk. The pickers contact the silken strands and carry them with the attached larvae to the hallocks of fruit. Thus the tortrix larvae get on the fruit and are carried to the canneries where their presence is objectionable.

Pandemis

The partly grown pandemis larvae overwinters at the base of the tree and begin feeding on foliage in April. They attack cherries where the larvae feed around the stem ends and sometimes bore into the fruit to the pit. They also feed in apricot fruits shortly before harvest. The larvae is light yellow-green with a *definite head and legs*. These characteristics distinguish it from the cherry fruit fly maggot, which is white, smaller, *headless, and without legs*. 58

Pear Psylla

One of the most injurious insects that attacks pears, the pear psylla (*psylla pyricola foerster)*, was discovered in the state of Washington for the first time in the Spokane Valley in July 1939. The insect was first found in Connecticut in 1832, presumably having been introduced into the United States from Europe. Since that time the psylla has spread over the eastern states into Ontario, Canada, on the north; North Carolina on the south, and as far as Illinois to the west. The infestation in Washington and Idaho is the only known infestation west of the Mississippi River. Psylla is reported to be the main limiting factor in producing pears in eastern states. In some orchards it has been so destructive and difficult to control that commercial pear production has become unprofitable. 71

The adult psyllids are about 1/10 of an inch long, dark reddish brown in color, and have transparent wings that slope roof-like over the abdomen.These adults pass the winter beneath the bark of pear and other trees, and beneath leaves and debris in and about the orchard.

They emerge from hibernation in the early spring. Soon after emergence, the female deposits small white eggs in crevices around the buds and on the smaller branches and fruit spurs of pear trees during the early stages of the swelling of the buds.

In Spokane county Washington in 1940, the first eggs were found on March 16 and egg deposition continued until shortly after bloom. Later in the season the eggs are usually deposited along the mid-rib on the underside of the leaves. The eggs hatch in nine days to four weeks, depending on the temperature. The majority of the eggs of the first brood hatch just before the buds begin to separate. In Spokane county in 1940 the first nymphs were observed on April 12. Each female lays approximately 500 eggs according to observations in New York state., The newly hatched nymphs migrate to the buds and settle on the leaf petioles and the fruit stems, where they feed by sucking out the plant juices. The nymphs pass through five stages (or moults), requiring approximately five days for each stage before maturing to adults. During the early stages the nymphs are yellow in color and covered with a drop of clear, sticky secretion called "honeydew". During the summer these nymphs are usually found on the underside of the leaves. In the later stages they are brownish black in color and are called "hardshells". Frequently these "hardshells" are found in the axils of the leaves. The first summer adults appeared about the middle of May in the Spokane area in 1940, with successive generations appearing at approximately one-month intervals. Observations indicate there may be at least four and possibly more broods each season in Washington. Therefore, a heavy infestation can build up from a few overwintering adults.

Pear Slug

The larvae of the pear slug are various shades of olive green. A covering of slime-like material gives them the appearance of slugs. The body is swollen in front and tapers behind like a tadpole. They feed on the upper surface of the leaves and may remove all except a fine network of veins. Badly injured leaves fall and the entire tree may be defoliated by mid-summer. The adult of the pear slug is a small glossy black four-winged fly about ½ inch long which deposits its eggs under the upper surface of the leaves. It overwinters in the pupal stage in an earthen cocoon in the soil. 58

Pea Weevil

The pea weevil is a hazard in the production of peas in any part of the United States and is of especial importance wherever extensive acreages of peas are harvested as dry peas, as is the case in Utah, Idaho, Washington, Oregon, and northern California. The pea weevil infests the pea in the pod and matures as the pea matures. Rotenone-containing insecticides, used in conjunction with proper sanitation, must be relied on for control. 124

The weevils fly into the pea fields at the end of the hibernation period, at a time which coincides rather closely with the blossoming period of the peas. The eggs are laid on living green pods only. Unlike some of its relatives, such as the bean weevil is incapable of breeding continuously in the dried seed.

The newly hatched larva is white and about one-sixteenth of an inch long. It continues to feed within the growing pea and increases in size slowly, gradually consuming a large part of the interior of the pea, while the pea continues to grow. The larva attains its full growth at the end of 5 or 6 weeks. At this time its body usually fills a large part of the interior of the pea, which has developed to the ripened stage. 124

Peach Twig Borer

This insect passes the winter as a partly grown brown caterpillar with a *black* head, form 1/16 to ⅛ inches in length, hidden in a silken protective covering or cells attached to the crotches of the younger branches. In spring the larvae leaves these cells and burrow into tender new growth causing a wilting and dying back of the twigs. These larvae mature, spin cocoons, emerge, mate and the second-generation eggs are laid. The borers emerging from thse eggs feed almost entirely in fruits of peaches, prunes, and apricots. There are two or more broods per year. 58

Peach Tree Borer

These insects are serious pests of peaches, apricots, plums, prunes, and occasionally cherries in some areas. The injury caused by the borers occur mostly in the crown of the tree roots. Their presence is first indicated by a quantity of gum mixed with dirt and frass at the base of the trunk. The adults are clear winged moths that lay eggs on the tree trunks in July and August. These hatch in about 10 days.

The young borers after hatching crawl down the tree trunks and enter the bark just below the soil surface where they pass the winter. There is one generation per year. Control measures may be applied in the spring or fall. The fall treatment is more satisfactory since it kills the borers while they are small before they are capable of causing much damage. 58

Plum Curculio

Plum curculio, a snout beetle with a strong curved beak about one-third the length of the body, is most serious pest of peaches and other tree fruits, see Fig. 19. The larvae feed in the fruit adjacent to the kernel, see Fig. 20. The adults are responsible also for spreading

Fig. 19.
Cambius Curculio

Courtesy U. S. Department of Agriculture
Bureau of Entomology and Plant Quarantine

brown rot by feeding and egg-laying punctures. Adults, when they come out of hibernation in the spring, are covered with dirt, and their coloring is obscure. However, they may be identified by the four humps on the back. They hibernate in woods or in the brush and trash close to their hosts, and start coming out of hibernation usually during the first ten days of April.

Fig. 20. Courtesy Penn. State College
Cambium curculio damage

On peaches the fuzz makes the egg punctures hard to see, but on plums and other smooth-skinned fruit the egg-laying punctures are easily detected. In the process of egg laying the female with her mouth first makes an incision through the skin and prepares a small hole; she turns and lays an egg in the hole, then with her beak pushes the egg down into the fruit. Next a crescent-shaped hole is cut in the skin around the egg, leaving a little flap. After hatching, the larvae bore into the fruit. They are legless, whitish, with curved bodies and small brown heads. Infested fruits soon fall to the ground where they may be picked up and destroyed. The larvae when mature bore out of the fruit and pupate in the soil. The adults appear again about the last week of June. 201

● RASPBERRY SAWFLY is a fly-like insect. The females lay their eggs upon the leaves, where the larva starts feeding. Serious infestations may partly eat off most of the leaves. The injury is most noticeable in May and June. 69

Raspberry Fruit Worm

A yellowish-brown beetle about 3/16 inch long. It feeds upon fruit buds, unfolding leaves, and blossoms. The feeding sometimes distorts

the berries. The female beetle fastens eggs to the blossoms just before they open. The full grown larva is about 1/3 inch long. It has light brown spots on the back of each segment. It tunnels the core of the berry and sometimes eats into the berry itself. The adult beetle overwinters in the soil and begins to come out in mid-April. 69

The first eggs are deposited at about the time the first raspberry and logan berry flowers appear, and are laid on buds or in the flowers. Incubation required varies from 9 to 24 days and the larvae enters the drupelets or the fruit pedicel within a few days after hatching. The larvae feed on or in the fruit for 26 to 45 or more days, depending on the host and the stage of fruit development, and then drop to the ground when fully fed. They burrow through the soil for several days before constructing their fragile pupal cells. Most of the larvae remain in the top three inches of the soil but a few may be found nine inches below the surface. Pupation occurs during the latter part of the summer and in the fall and, although the adults are fully colored before winter, they do not leave the pupal cells until spring.

● RED SPIDER — (See Mites).

San Jose Scale

Is a small insect that lives under a round or oval scale-like, grayish covering, which is a waxy secretion given off from the insect's body. It attacks all of our fruit trees and many shrubs. Heavily infested trees show a lack of vigor; the foliage becomes yellowed and spotted because of the scales on the leaves. The insect also feeds upon the fruit, as indicated by the small, red area surrounding each scale. There are a number of different kinds of scale insects, see Fig. 21.

Fig. 21. Courtesy U. S. Department of Agriculture
Oystershell Scale

The scale was introduced into this country from China and was first found near San Jose, California, in 1880. It shortly attained greater notoriety, caused more legislation, and did more injury to the

fruit interests of the United States and Canada than any other insect. At the present time this pest may be considered of lesser importance, since a very simple method of control is available and in common use.

The insects pass the winter usually in the smaller, immature stages and become mature about the time apples bloom. The mature male comes from a circular scale with a raised nipple in the center, while the female develops under the oval-shaped scale. The adult male is a very small, two-winged insect which moves about; the female remains under the scale and produces living young, which look like small mites or lice. These young move about for a short time, find a place to insert their beaks, and begin sucking sap. In a short time they shed their skins and appear as small yellow sacks fastened to the bark by mouth parts, and soon a waxy secretion from the insect covers the body to form the scale.

San Jose scale is controlled by a spray containing emulsified engine oil, applied when the trees are dormant. The oil kills by smothering the young scales; therefore, a very thorough spraying must be done. If less than 99 percent kill is obtained the treatment may be considered unsatisfactory, since the scales multiply very rapidly. The percentage of kill may be determined about a month after spraying, by turning over the scales with a knife or pin point. Live scales are little, plump, yellow sacks; dead scales are dull yellow and dried out. Do not examine for kill after rains, as the dead bodies often soak up water and appear alive. 201

Shot-Hole Borer

The shot-hole borer is a small black beetle which bores into the sap wood of the trees late in the fall and early spring. It lays its eggs in tunnels which it makes in the wood. The eggs hatch out into larvae which overwinter under the bark of trees. There are probably two generations per year. 58

Syneta Leaf Beetle

This insect occurs in April and May on foliage, fruit clusters, and in open blossoms as a creamy-white beetle about ¼ inch long. It eats holes in the leaves and blossom petals and gnaws out small cavities in fruit stems. The syneta beetle is especially injurious to cherries. 200

Stone Fly

Stone flies injure buds of peaches in some areas along the Columbia River. Their feeding on buds and blossoms causes a blemish known as *monkey face*.

Strawberry Weevil

Strawberry weevil—only about 1/10 inch in length—is smaller than the other weevil just discussed and is brownish-black. The female lays an egg in the bud and then will cut a notch in the bud stem. The attack leaves the bud hanging on a partly severed stem. Infested buds soon fall to the ground, where the larvae complete their growth. The adults come out of hibernation rather early and attack the buds of strawberry, blackberry, and related plants. 201

Tarnished Plant Bug

It is a general feeder and is recorded as attacking 50 or more economic plants, besides many weeds and grasses. This habit greatly complicates the effective use of insecticides and the protection of flowering plants. Both the nymphs and adults, when feeding, sting the young tips, and especially the buds of dahlia, and cause them to become "blasted" and die. They also puncture the leaves so that small spots appear in the areas fed upon. While feeding, the tarnished plant bugs seem to inject a poisonious substance into the plant, killing the surrounding tissue. The adult is a small, brownish fattened bug, about ¼ inch long. It has a brassy appearance and is marked with yellowish and black dashes. The adult hibernates under leaf mold, stones, or bark of trees, or among leaves of clover, alfalfa, and mullein and in other protected places. They appear in early spring, and the bugs are most numerous by late summer. Their eggs are laid in the stems, petioles, buds, and tender growths of any herbaceous weeds and garden plants. 61

Fig. 22 Tarnished plant bugs (lygus)
Courtesy U. S. Dept. of Agriculture

Tobacco Flea Beetle

Tobacco flea beetle is a small, active insect, with greatly enlarged hind legs, which enable it to jump away like a flea when disturbed. It is most injurious in early spring. The adults overwinter in litter close to their food plants. They come out of hibernation early and attack plantbeds, young seedlings, or transplants. The beetles eat small holes in the leaves, often sufficiently numerous to kill the plants. They probably spread diseases.

This pest attacks potato, tobacco, eggplant, jimson weed, and a large variety of other plants. The larvae feed on the roots of the same plant that are attacked by the adults, but little is known as to the extent of the injury they cause. 201

Tomato Fruit Worm

The tomato fruit worm is also known as (corn earworm), (cotton bollworm), see Fig. 23. The tomato fruit worm passes the winter in the pupal stage. Adults or moth emerge during late spring and lay eggs on various plants, such as vetch, tobacco, corn, and, later in the season cotton. From its wide range of host plants, the insect has acquired a number of names descriptive of its hosts, such as corn earworm or shatterworm, tobacco budworm, and cotton bollworm. Several generations are produced each season. Four stages are required to complete a generation; namely, egg, larva, pupa, and adult or moth.

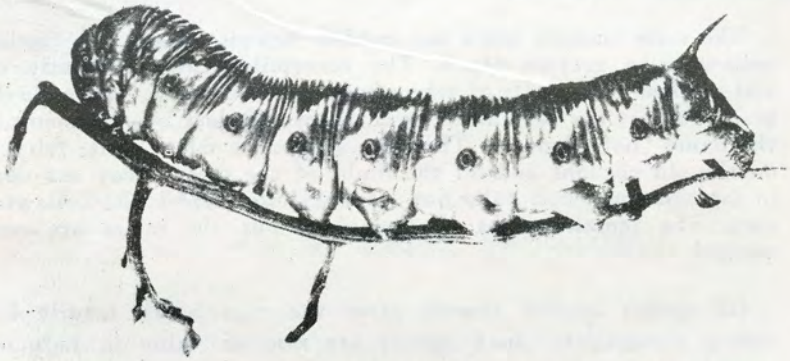


Fig. 23.
Tomato Hornworm

Courtesy U. S. Department of Agriculture
Bureau of Entomology and Plant Quarantine

The worms are rather restless and shift from one fruit to another so that a single worm may ruin a number of fruits without eating the equivalent of a single one. Studies by the Bureau of Entomology show that a single worm may ruin as many as seven fruits. 204

KNOW YOUR PESTS

Thrips

There are a large number of different kinds of thrips such as the gladiolus, onion, citrus, and greenhouse thrip. They are minute in size, usually yellow or brown. They are very active and attack younger leaves and fruit. See Fig. 24. In many states thrips are a serious pest to onions. Control is usually obtained with naphtalene or mecuric chloride applied to the onion sets. In the field DDT, chlordane or toxaphene sprays will give good results.

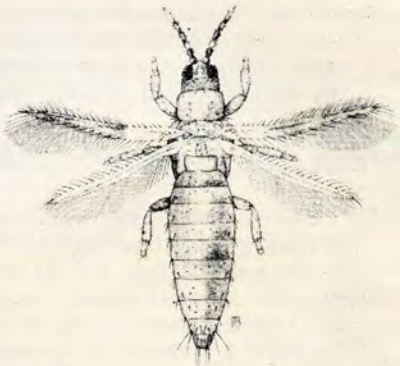


Fig. 24. Thrips (greatly enlarged)
Courtesy U. S. Dept. of Agriculture

Tussock Moth

The male tussock moth has reddish brown wings. The females are yellowish to greyish black. The caterpillars are brilliantly colored and clothed with tufts of white hair on the dorsum, and a single long black tuft at the rear and two in front, the last being responsible for the name "horn worm". The eggs appear as white, flat, felty masses on the old cocoons and on the limbs of the trees. They are deposited in late summer and fall, but do not hatch until the following spring. The female moths are wingless, but the males are normally winged.

Oil sprays applied shortly after the eggs hatch readily kill the young caterpillars. Such sprays are also of value in reducing the codling moth, skinworms, pandemis, cankerworms, bud moths, and others.

Webworm

The several webworms are very much alike in appearance and life history. Larvae of the garden and alfalfa webworms vary from a light yellowish-green to nearly black with a broad light central stripe and three dark spots on the side of each segment; larvae of the beet webworm are similarly colored but have a narrow black stripe down the middle of the back. When mature, the larval webworm measure from one to one and one-quarter inches in length. Adult moths of webworms vary in color from the light brown spotted moth of the garden and alfalfa webworm to the greyish-brown spotted and lined

moth of the beet webworm. The adults vary in size from three-quarters of an inch for the garden webworm to one and one-quarter inches for the alfalfa and beet webworm.

Mature webworm larvae pass the winter in the silk-lined burrows or cases, pupate in the late spring and emerge as adults lay their eggs on the under side of leaves in masses of two to fifty. The light yellow to yellowish-green larvae hatch and begin feeding and spinning their webs to complete the cycle. In Nebraska there are probably only one or two generations produced during the summer months. In heavy infestations, when all available food has been eaten, webworms sometimes migrate much like army worms.

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PART TWO

WEED IDENTIFICATION

The use of chemicals for weeding is now an established practice in the production of vegetable crops in most states. Carrots, onions, asparagus, peas, sweet corn and many other vegetables give excellent response to chemical weed treatment. Chemicals reduce the cost of hand weeding and add materially to the yield.

Part Two of this book gives the identification of common weeds and, general discussion of their control. Elsewhere under the discussion of individual crops is additional specific information on many common weed pests.

Crop Losses

Weeds cause tremendous losses to farmers. They work silently but well. They do not make a lot of noise or demand a fanfare but exact their toll every year. There are many weed pests present in every state.

Weeds cause reduction in yields by actually using food and water present in the soil. Every pound of water used by weeds cannot be used by the crop in which the weeds are growing. Most crops require from 400 to 900 pounds of water to produce one pound of dry matter. In some cases the crop of weeds may weigh several tons per acre thus reducing the crop yield markedly. If weeds get started ahead of a crop or grow more rapidly, the crop may be shaded so severly it can never produce a normal crop. Many weeds act as intermediate hosts to disease—necessary in the life cycle of the disease.

The quality of farm products is often lowered considerably by the presence of weeds or weed seeds in the hay or grain. Weeds are expensive to control. Extra cultivations, chemicals and equipment for control add materially to the cost of production. Many weeds are poisonous to various kinds of livestock while others cause only mechanical injury to animals by forming compact balls in the stomach or by beards or awns getting into gums, eyes and flesh.

Certain types of weeds grow in water. They clog irrigation ditches or drainage ways oten so completely that the flow of water may be completely stopped. 179-121

Weeds cost American growers 5 billion dollars annually. Weeds lower crop value up to 50 per cent. Weeds clog irrigation and drainage ditches. Weeds produce an enormous number of seeds per plant, as high as 50,000. One pound of dry weed matter requires from 3 to 700 pounds of soil water. 103

An Alarming Menace

Noxious weeds are slowly but surely choking many valuable lands out of production throughout the entire United States. Growers often fail to recognize and identify weeds until they have become solidly established. Already weeds are costing the United States well over 5 billion dollars a year. Soon the cost of eradication is going to be prohibitive unless they are quickly gotten under control.

Considerable progress has been made in weed control through the state weed control laws. Many more weed control districts are needed, however, to make the program effective. Weed control today costs money but the present cost is insignificant compared with what it will be in a few years unless drastic control measures are adopted by individual growers.

In many cases weed infestation has become so severe that farm land has been abandoned; range land will support only a fraction of the cattle or sheep normally grazed on the range before over-grazing killed the desirable species and weedy species appeared; much money must be spent in keeping irrigation and drainage ditches free of weeds that retard water flow. 121

HOW ARE WEEDS CONTROLLED?

Control of weeds through biochemical selectivity depends upon the susceptibility of the plants. Weeds and plants growing together have varying degrees of susceptibility to the cemicals. Some plants are easily damaged by certain toxic chemials others are only moderately or not at all affected. For a more detailed discussion of the chemical action which takes place in weed killing, see Book One, Part Three of this series.

Selective Weed Killing

Weeds can be controlled chemically after the crop has started to grow. Selective herbicidal treatments which kill the weeds alone can be carried out directly in a growing crop. Selective weed control depends, for the most part, upon the resistance of particular crops to specific herbicidal chemicals. Consequently, although in selective treatment weeds and crops alike receive the spray—the susceptible weeds die and the resistant crop plants are not affected. Selective weed control is a safe, successful method of controlling weeds in crops where a mechanical cultivation is impossible, such as in small grain. The herbicide, properly selected, does not injure crops when the rate and concentration of the spray is carefully controlled. The timing of application is also important. Weeds are killed most successfully when

they are young and tender. 103 There are many factors affecting the results of weed control, see Figures 25 and 26.

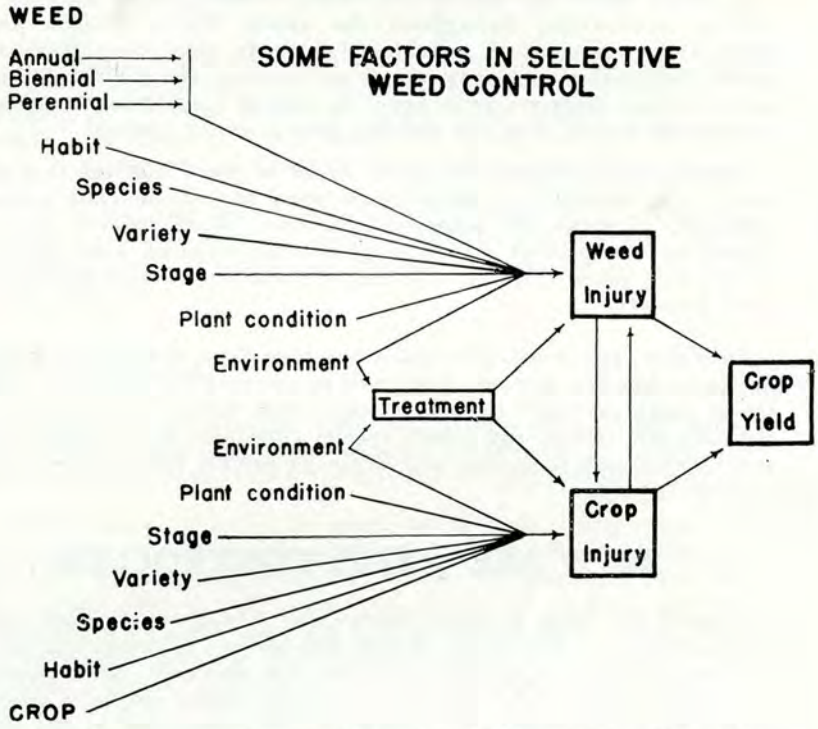


Fig. 25. Courtesy University of Idaho, College of Agriculture
Factors in Selective Weed Control

Non-Selective Weed Control

Killing *all* vegetation growing in a particular area is the most simple application of chemistry to weed control. The operation amounts to, simply, a thorough wetting of the weed foliage with a contact or general weed killer spray. Non-selective herbicides are generally used along railroad rights-of-way, on ditch banks, around sidewalks, and in fire lanes. By spraying a properly selected and formulated herbicide, grasses essential to prevent erosion need not be killed. Consequently, weed control sprays may be used along roadsides, on urban real estate, and on wastelands where it is desired to destroy the weeds but retain the grasses. 103 See Fig. 23 for a diagram of factors which affect non-selective weed control.

General Practices in Weed Control

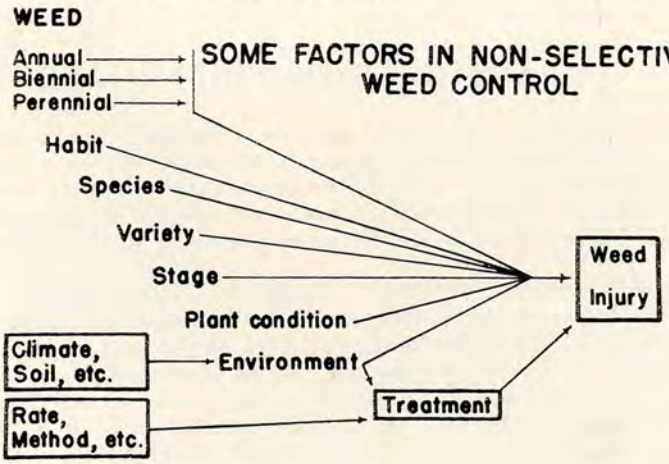
● DON'T SPRAY UNLESS JUSTIFIED: A field must be weedy enough to benefit materially to justify the cost of spraying. In other words, the expected increase in yield must more than justify the cost of spraying. *Reliable applicators will not do the job if the condition does not warrant the cost.* Reliable applicating companies want continued business.

Fields treated for weeds are easily harvested. There are no delays because of green weeds fouling the harvest equipment. Grain from 2,4-D treated fields is practically free of dockage at the elevator. Germination, test weight and protein content are not reduced by using 2,4-D instead increases have been reported.

● TOO EARLY SPRAYING MAY MISS LATE SEEDLINGS: The principal drawback to early spraying is that some weed seeds may germinate after the spray treatment and bring about reinfestation. This is not a serious problem in cereal crops because the crop is sufficiently developed before reinfestation so that it can compete successfully with the weeds. In onions, carrots, milo, and other truck and field crops that are intertilled or planted less densely, however, this may be a real problem. A possible answer is a combination of a preemergence spray with one or more selectives.

● WEEDS USUALLY ARE EASIEST TO KILL WHEN YOUNG: According to A. H. Larson, speaking before the 1949 North Central Weed Control Conference, starting with the 2 to 3 true leaf stage of

Fig. 26. Courtesy University of Idaho, College of Agriculture
Factors in non-selective weed control



weed seedling and continuing up to the stage where seeds are beginning to develop there is a progressive reduction in the effectiveness of most of the chemical formulations. 207 This means that more chemical is needed to produce the same results as the weed grows older. It also means when *crop* conditions permit it by all means try to treat the weeds while in the 2 to 3 true leaf stage. 209

● ADVANTAGES OF AIR-APPLIED CHEMICAL WEED CONTROL: Air-spraying is many times faster than ground spraying, manual cultivation or hoeing. When other farm work is pressing, often weeds are neglected. Weed spraying can be done economically by custom air-application thus eliminating the investment in ground equipment. Weed control by aerial spraying eliminates weeds early—before they have had time to compete materially with the crop. New weeds take considerably longer to appear after a spraying than after a cultivation. Air-application avoids root damage to crops. Crops can be treated by air when soil is too wet for surface vehicles. Crops where seed is broadcast can be treated by air where such treatment would be impossible by ground rig due to wheel damage. Air-application kills seeds which would be drilled into the ground by ground rig. 103

Types of Weeds

● ANNUALS are those completing their life cycle in one year. These can be controlled by cultivation or mowing prior to seed formation or in some cases by spraying with selective weed killers.

● BIENNIALS: Requiring two years to complete their life cycle. Control of this type of weed is usually most successful in the first year of growth. This prevents seed formation and allows for control before the weeds become well established.

ANNUALS AND BIENNIALS

The following paragraphs describe a number of the most common annual and biennial weeds. Annuals are relatively easy to kill. 2,4-D is highly effective on most of the broadleafs and other equally effective chemicals are available for use in the control of the grassy types of weeds. These chemicals are discussed elsewhere in this volume.

● BLACK NIGHTSHADE, DEADLY NIGHTSHDE: (Annual) Fig. 27, tap-root short, slender; stems smooth, erect, 6-36 inches tall, branching in the upper portion; leaves egg-shaped, smooth, the edges somewhat wavy or sawtoothed, borne alternately on short stocks; flowers in small, hanging clusters on long stocks attached to the middle of the branches between the leaves, smaller than in 93 and 94 but similar in shape; corolla (petals) white; berry black, smooth, spheri-

cal; seed somewhat egg-shaped, flattened, dull yellowish or dark brown, about 1/16 inch long, the surface pitted. Found in old fields, grassy fence-rows, dumping grounds. 293

● BULL THISTLE: (Biennial) Fig. 28, 2-6 feet tall, with a deep fleshy tap-root differing otherwise from Canada Thistle in the following respects; stems wooly-hairy, winged with the prickly bases of the leaves which extend downward from the joints; upper leaves long-pointed; flowerheads pinkish-purple, very sharp spiny on the outside; seeds slightly larger, light brown, marked with darker colored longitudinal lines. Found in pastures, old fields and yards, and roadsides. 293

Fig. 28. Bull Thistle

Fig. 27. Black Nightshade

● BURDOCK: (Biennial) Fig. 29, tap-root rather deep, about the diameter of a finger; stem erect, branching, rough-hairy, 3-9 feet tall; leaves large, nearly egg-shaped, the margins uncut or slightly toothed, rough on upper surface, whitish-hairy on lower surface, alternate, on thick stalks; flowerheads with pinkish-purple flowers protruding from the upper end, nearly spherical, covered on the outside with hooked bristles, borne in small clusters from the bases of the leaves and branches; "seed" oblong, usually curved, triangular or square in cross-section, the surface with minute vertical ridges, brown, bearing at the top a group of hairy scales which soon fall off.

Found in yards, especially neglected barnyards, and dumping grounds. 293

● CHARLOCK, WILD MUSTARD: (Annual Fig. 30) tap-root about the width of the stem, not much branched; stems erect, branching in the upper part, usually hairy on the lower portions, not developing from a basal cluster of many leaves (rosette) in the spring; upper stem-leaves somewhat foursided, irregular cut into short teeth on the margins, alternate; lower leaves usually more deeply cut into irregular pairs of longer, tooth-like portions; flowers yellow, borne in finger-like clusters; seed-pods smooth, the upper third a solid, two-edged beak, spreading out from the stem on short stalks; seed nearly spherical, about 1/16 inch in diameter, black or dark brown, the outer coat either finely net-like in appearance or smooth. Found in fields, roadsides, and similar places. 293

Fig. 30. Charlock, Wild Mustard

Fig. 29. Burdock

● COCKLEBUR: (Annual) Fig. 31, tap-root rather woody, stout and deep; stems erect, about 1½-3½ ft. tall, branched in the upper portion, ridged, rough-hairy and

with small dark red spots; leaves rough-hairy, upper surface dark or yellowish-green, lower surface pale green, variable in outline from broadly egg-shaped to nearly heart-shaped, the edges sometimes cut somewhat so as to resemble the general outline of a maple leaf, often lobed, and usually cut into coarse teeth, borne alternately on long stalks; flowerheads of 2 kinds; pollen-producing heads nearly round, small, in crowded clusters at the tips of the short branches which bear the burs; seed-producing heads becoming very hard, covered with usually hooked spines, nearly oval or elliptical in general outline, about ¾-1 inch long, in crowded clusters on short branches; "seeds" 2 in each bur, ⅜-⅝ inches long, flattish, oblong with pointed tips, dark brown or black. Found in cultivated and old fields, pastures, roadsides, and similar places. 293

Fig. 31. Cocklebur

Fig. 32 Crab Grass

● LARGE CRAB GRASS, FINGER GRASS: (Annual) Fig. 32, with somewhat spreading stems, frequently rooting at the lower joints; stems about 12-46 inches tall; leaf sheaths and blades hairy, the latter 3/16-7/16 inches wide; flowering branches 4-7, radiating

outward from the top of the main stem, or 1 or 2 side branches; small individual flowers in two rows on one side of the flattened stalk; grain narrowly oval, light yellow, about 1/16 inch long. Found in cultivated soil, frequently in corn fields, lawns, roadsides, and recently abandoned fields. 293

Fig. 33 Lamb's Quarters

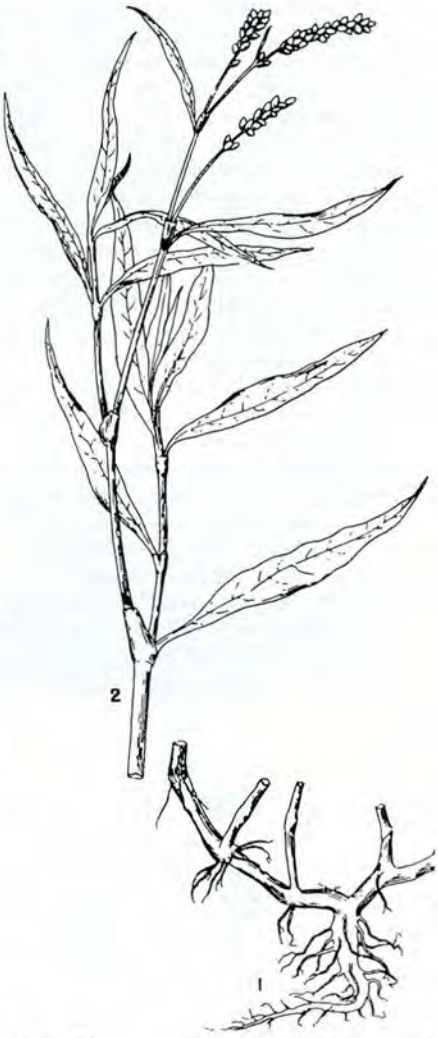


Fig. 34 Pennsylvania Smartweed

● LAMB'S QUARTERS, WHITE GOOSEFOOT: (Annual) Fig. 33, tap-root usually unbranched, sometimes deeply penetrating the soil; stems erect, smooth except for verticle ridges, 1-6 feet tall; leaves alternately attached, without st-

alks, grayish-green on the under surfaces, the edges irregularly toothed, varying from egg-shaped to narrowly spear-shaped (uppermost); flowers greenish, very small, in clusters developing from the ends and sides of the stem and branches; seed flattened, nearly round, shiny black, about 1/16 inch in diameter, enclosed within a thin, papery coat which readily rubs off. Found in cultivated ground, fields, yards, dumps, and similar places. 293

Fig. 35. Prostrate Pigweed

● PENNSYLVANIA SMARTWEED, LADY'S THUMB: (Annual) Fig. 34, stems mostly erect, 8-24 inches tall, smooth except for sticky-hairy upper branches and main flower stalks; leaves spear-shaped, smooth on the lower surface, not particularly peppery to the taste; flowers in short, upright, rose-colored, finger-like clusters; "seeds" round in shape, usually 2-sided, shiny black, about 1/8 inch long. Found in low, wet cultivated ground, pastures, fields, ditches, banks of streams and ponds. 293

● PROSTRATE PIGWEED, SPREADING PIGWEED: (Annual) Fig. 35, tap-root short; stem reddish, nearly smooth, generally spreading flat over the ground, but mostly erect at the tips; leaves are small, alternate, about ½ to 2½ inches or more long, mostly egg-shaped with the broader end uppermost; flowers small, greenish, in small, dense clusters at the base of the leaf stalks; seed flattened, nearly circular, shiny black, 1/16 inch in diameter. Found in neglected fields, unused yards, and similar places. 293

● PURSLANE, PUSSLEY: (Annual) Fig. 36, root short, branching; stems smooth, juicy, somewhat reddish, usually spreading over the surface of the ground in mats; leaves usually alternate, generally egg-shaped with the broader end uppermost, juicy; flowers open only in the sunshine, consisting of 5-6 small yellow petals and a two-pointed green calyx below; seed-

pod opening when ripe by splitting across the middle into two halves; seed about 1/32 inch long, slightly shiny, black, egg-shaped, with the rounded margins covered with rows of very small curved projections on the surface. Found in cultivated ground, yards, lawns, and similar places. 293

● TALL HORSE-WEED, FLEABANE: (Annual) Fig. 37, tap-root short, slender, stems erect, 3/4-6 feet tall, bushy-branched in the upper portion, rough-hairy, narrow, very numerous, only the lower ones with slightly toothed edges and tapering at both ends, the upper ones stalkless with smooth edges, alternate; flower-heads small, about 3/16 inches across, cylindrical when young, the centers yellow, the very narrow, petal-like flowers numerous (in excess of 100), short, greenish-white; "seed" hairy, narrowly oblong, flattened, with a tuft of hairs at the top. Found in cultivated, recently abandoned and old fields, pastures, and roadsides. 293

Fig. 36. Purslane, Pussley

Fig. 37. Tall Horse-weed, Fleabane

TIMING FOR SMALL GRAINS

Practically all annual weeds are best controlled by treating them when small and while in a soft, vigorous growth condition. Resistance increases as they approach maturity or when they are subject to adverse growing conditions, while most perennial weeds are

best controlled by treating them in the early bud to early bloom growth stages.

Crop plants are least susceptible to damage at these indicated periods:

Winter wheat, barley, oats—safest between well stoled and boot stages, and again after grain in dough. See Figures 38 and 40. Fig. 39 shows the wheat plant with a central stem and two *tillers* (branches). Some studies have indicated that spraying before the tillers are well developed may result in a deformity of the heads. These deformities, however, have not caused reduction in yield. When no new tillers appear the plant enters the jointing stage. Fig. 40 shows the wheat plant in the *boot stage*. The top leaf sheath is swollen because of the enclosed head which is soon to emerge. This is a dangerous period in which to spray. 165

Spring wheat, barley, oats—safest after 6 inches high and before boot stage, and again after grain in dough.

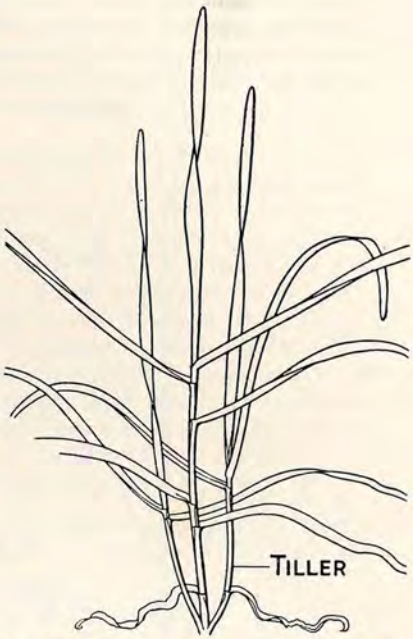


Fig. 29. Tiller Stage
Courtesy University of Minnesota College of Agriculture

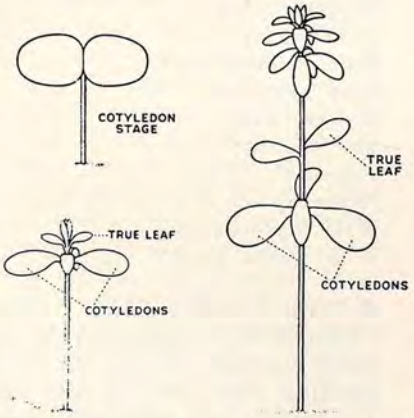


Fig. 38. Cotyledon stage
Courtesy University of Minnesota College of Agriculture

Corn apparently is safest when between 4 and 12 inches high (Use amine in water only). Never spray corn during the tassel stage.

Flax may be sprayed safely between the true leaf and the prebud stage. (Use amine in water only). See Fig. 38 which shows the cotyledon and the two true leaf stages of flax. It is usually safe to spray after the catyledons have appeared but as a rule this is too early for weeds.

It is also believed to be safe to spray during the true leaf stage.

The third drawing shows the flax during the period of rapid stem lengthening. If possible, spraying should be avoided during this rapid growth. The dangerous or most *susceptible* period for injury to flax, however, is from the immediate pre-bud stage to full bloom. Spraying must be avoided during this period. 165

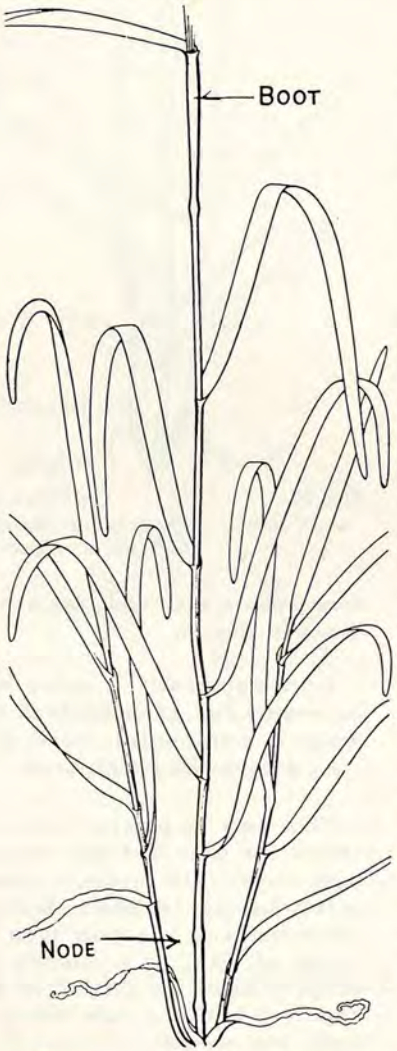


Fig. 40. Boot stage
Courtesy University of Minnesota College of Agriculture

PERENNIALS

Prennials: live for more than two years. Many of them not only produce seeds but also spread by means of underground rootstocks. Small pieces of these rootstocks can give rise to new plants even when covered to considerable depth in the cultivation process. 179-121

The more common perennial type weeds are:

Blue lettuce
Canada thistle
Crowfoot
Field bindweed
Hedge bindweed
Horse nettle
Leafy spurge
Milkweed or blue lettuce
Poverty weed
Quackgrass
Russian knapweed
Sand sagebrush
Skelton weed
Sow thistle
Tanweed
Whitetop
Wild morning glory
Wild sweet potato

● TIME FOR SELECTIVELY TREATING PERENNIALS: Actually you must be guided by the growing condition of the crop. Treatment for perennial weeds, however, should be delayed until after the weeds are 12 or more

inches high, while they are growing vigorously but before they bloom. To spray before this would fail to affect the additional shoots from the roots of the bendweed (morning glory) and many perennials whose shoots are not through the ground when the grain is 4 to 6 inches high. For best control perennials should be sprayed again after harvest.

The principal aim in treating perennial weeds is to kill their underground parts. This is necessary for complete control of such weeds since these parts—roots, stolons, bulbs, or rhizomes—are able to live and send up new plants even after the above ground plants have been destroyed.

● REPEATED APPLICATIONS ARE NECESSARY: The killing of perennial weeds is difficult. Some think that perennial weeds have the ability to block off the movement or so reduce the concentration of 2,4-D or 2,4,5-T that all the roots of such weeds are not killed. Many of these weeds have dormant buds on the horizontal roots which can produce new plants if the chemial is stopped or dissipated in its flow toward the root tip. Thus, if small pieces of the root are not killed they usually produce new plants. This explains why repeated sprays are necessary for killing these new plants which are growing from the small segments left by the original spray. These repeat sprays should be applied when the resprouts are in the rosette state (4 to 6 inches high) so as to kill out the small plants before they have an opportunity to produce long horizontal roots again. (Because of wide variation in soil moisture, humidity, etc., local and state authorities' recommendations should be considered.) 134

● SEEDING PROBLEM: Regardless of the method of controlling weeds, the problem of re-destroying the new crop coming up from the seeds in the soil is always present. Some weed seeds will live a great many years in the soil and will germinate when conditions of light, water and temperature are optimum. It is estimated that some weed seeds will live as much as 20 years in the soil and still be capable of germination.

This seedling problem is particularly important with respect to

Fig. 41. Canada Thistle

the serious perennial noxious weeds. The original infestation may be completely killed, but if it has ever been allowed to go to seed there is an ever-present source of a new infestation. The perennial species are as easily killed as annuals during the first six to ten weeks of their life. After that period, however, they begin to develop perennial characteristics of deep-rooting, root-stock development, etc. The longer control is delayed the harder they will be to control. 179

IDENTIFICATION OF PERENNIALS

The following paragraphs describe some of the most common perennials.

● CANADA THISTLE; known as creeping thistle and small-flowered thistle, Figure 41, is a perennial, growing three to six feet high, leaves spiny, clasping the stem, and very irregular and wavy of margin, green in color on both sides. Usually found in patches varying in extent from a few square feet to an acre or more. In these patches all other vegetation is crowded out. The plants branch freely at the top, and are covered with flowers ½ to ¾ inches in diameter, usually purplish in color. The top-most buds bloom first.

Fig. 42. Leafy Spurge

Canada thistle propogates by both seed and rootstalks. The rootstalks grow down several feet into the ground. To eradicate this plant, repeated sprays are necessary. Make the first application when the plant is in the bud stage and repeat application each time when the new shoots which come up from the dormant roots buds are in the rosette stage, 4 to 6 inches high.

● LEAFY SPURGE: Leafy spurge Fig. 42, is a long-lived perennial herb with a milky sap. It propagates both by seed and by underground roots. The roots are reddish brown in color and may penetrate the soil to a depth of four feet or more. It usually occurs in clumps or patches.

The stem is usually unbranched except for the branched flower cluster, erect, and from 1 to 3 feet tall. The leaves are bluish green in color, long, narrow, (about ¼ inch wide), and have an entire (untoothed) margin and arranged alternately on the stem.

During the late summer the leaves become brownish-orange in color. The plant is among the first to resume growth in spring.

The flowers are very small, inconspicious, greenish-yellow when young, becoming more yellow as they mature. They occur in small clusters with rounded leaves, and resemble dense tufts of small leaves more than ordinary flowers. They occur mostly in umbrella-like clusters at the top of the stem. The seeds are light gray, smooth, and about twice the size of an alfalfa seed. They are borne in a three-sided capsule.

● MORNING GLORY: (Wild) (Small-flowered morning glory; field bindweed; European bindweed; love-vine; creeping Jenny): Wild morning glory, Fig. 43, is a perennial plant usually growing in patches. The small pink or white funnel-shaped flowers are about 1 inch in diameter and often grow in pairs. They close up in the evening and during rainy weather. The leaves are shaped like blunt pointed spearheads. Long cord-like roots grow out in all directions and form buds which send up new shoots. New plants may start from any part or piece of the root.

The seeds (two to four) are produced in round capsules. They are about 1/5 inch long, dull black to dark brown, oval, one face convex, the other angled with flat sides, surface coarsely roughened.

Wild morning glory ranks as one of the worst weeds in the midwest. It trails over the ground with a persistency which fills farmers with dismay. Field bindweed is most susceptible to 2,4-D when just starting to bloom but may be controlled at other stages if growing vigorously. 1-1/3 to 2-2/3 pints of WEEDONE CONCENTRATE 48 or 1 to 2 pints of WEEDAR 64 or WEEDONE LV-4 per acre is required to give practical control of this weed. 134

● POISON IVY: (Perennial) woody vine or shrub, Fig. 44, of-

Fig. 43. Morning Glory - Field Bindweed

ten climbing by short rootlets on trees or fences; stems smooth, light brown or grayish in color; leaves alternate, each leaf consisting of three large, broad, shiny leaflets, the edges of which are either smooth or irregularly toothed; berries greenish-white, nearly spherical, smooth, about ¼ inch in diameter. Found in open woods, fence-rows, old fields, wooded banks, and thickets. 293

● POVERTY WEED (Salt sage; small flowered marsh-elder): Poverty weed, Fig. 45, is a coarse perennial herb with a rank, unpleasant odor. It is pale green in color and grows in dense patches. The stems are 8 to 18 inches high and branch very little. The leaves are small, numerous, and have no petiole. The small greenish flower heads are borne in the axils of the upper leaves. Poverty weed develops an extensive system of horizontal roots by which it spreads and makes eradication more difficult. The seeds are about ⅛ inch long, color variable, olive green, brown to almost black; pear shaped, slightly flattened, striated lengthwise, often keeled on the sides and slightly curved toward the base. The pest is well named poverty weed. The damage done is directly in proportion to the area and value of the land it covers for it forms a pure stand, crowding out all other vegetation. It seems to have a slight preference for either alkali or heavy land, though it occurs in the best of soil. Few farmers will give the time and effort necessary to eradicate it.

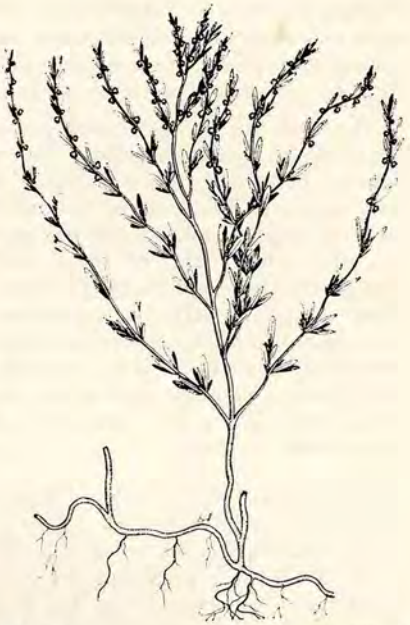


Fig. 45. Poverty Weed

Fig. 44. Poison Ivy

● QUACK GRASS (Couch grass, Witch grass): A dark green perennial grass, 2 or 3 feet tall. See Fig. 46. The character of the heads

is shown in the picture. Quack grass produces a perfect mat of underground root stocks that run close to the surface of the ground and send up innumerable new stems. The result is an unusually dense growth and a very compact sod. Those who are unfamiliar with quack grass may confuse it with western wheat grass, sometimes called common blue joint or blue stem. The seeds of quack grass, including the scales, are about 3/8 inch long, the outer scales are smooth and strongly nerved, pointed and terminating in an awn 3/16 inch long. The kernel is about 3/16 inch long, with a wide open groove resembling a small grain.

Quack grass is propagated both by seeds and rootstalks. Pieces of the latter grow readily when carried about the field by cultivators. Quack grass thrives in most soils and competes successfully with all crops but requires considerable moisture for vigorous growth. It is grazed readily by livestock and is not generally discriminated against in pastures. It also makes fair hay. Generally speaking, however, its objectionable features off set its advantages and under most conditions it is considered to be a bad weed.

Fig. 46. Quack Grass

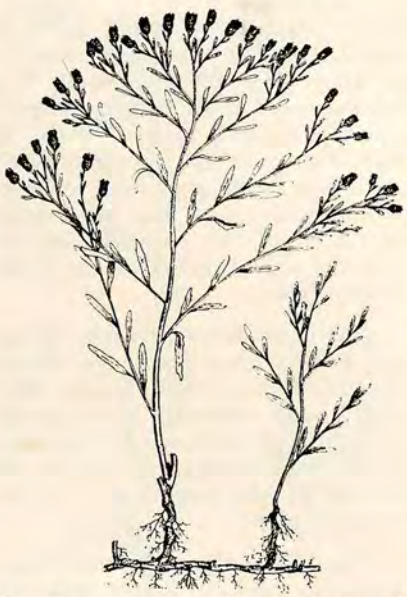


Fig. 47. Russian Knapweed

● KNAPWEED (Russian) (Turkestan Thistle): Russian knapweed, Fig. 47, has been recently introduced with imported Turkestan alfalfa seed. It may be distinguished from most other perennial weeds by its lilac-colored flowers in small round heads, and by the tough dark brown or black perennial roots.

The leaves on a mature stem are small, narrow, with smooth surfaces and edges, and without

a pronounced midrib or stalk. Short, stiff hairs cover the leaf and stem. The leaves get smaller as they approach the head. The whole stem is hard, rough and practically inedible when dried in hay. The young stems are covered with long, soft, gray hairs or nap, which remains on the lower part of the stem. This nap does not appear on the branches of the flowering stalks.

The first leaves which appear in the spring are large, thick, grayish-green, much longer than wide, with rounded teeth on the margin and covered with nap. These leaves are very unlike the leaves on the upper part of the mature plant.

The lilac-colored flowers are borne in small, almost spherical heads, 3/8 to 1/2 inch in diameter.

Fig. 48. St. John's Wort

The flowers somewhat resemble those of Bachelor's Buttons, only smaller. The small heads and the absence of thorns or prickles, distinguishes the knapweed from any thistle. The seeds are about 1/8 inch long, approximately twice as long as broad, chalky white, sometimes having a tinge of yellow, slightly wedge-shaped, marked with fine longitudinal lines.

Russian knapweed has gained a foothold in many counties in Montana and due to its persistence, its capacity to spread, its density of growth, its presence in hay and pasture, the farmers of the state must learn to farm in the presence of this noxious weed.

● ST. JOHNS WORT: Perennial herb), Fig. 48, tap-root short; stems tall, 10-32 inches, smooth, somewhat 2-edged, much branched in the upper portion, producing runners from the base; leaves elliptical or narrowly oblong, the edges smooth, stalkless, in pairs on the stem and branches; flower clusters somewhat flat-topped, crowded at the ends of the stem and branches; flowers large, yellow, with 5 petals bearing black dots on the margins, and many stamens in 3 clusters; seed-pod hard, brown, pointed, splitting into 3 sections when ripe; seed oblong, about 1/32 inch long, shiny dark brown, the surfaces covered with rows of minute squarish pits or depressions. Found in open or rocky pastures, grasslands, old fields and roadsides. 293

● SKELETON WEED (Rush pink, wild asparagus): Skeleton weed is a perennial plant and appears leafless, the leaves being very small

and scale-like. It grows 6 to 24 inches high. The branches of the plant are slender, hard, wiry, and contain a milky juice. The flowers are about ¾ inch in diameter, light purple, and appear from July to September. The seed is about 1/5 inch long, very slender and dull in color, and is easily blown about by the wind. Skeleton weeds usually occur on non-irrigated, sandy or sandy-loam soil, under some conditions competing seriously with cultivated crops. It spreads by wind-borne seeds and under ground roots.

● SOW THISTLE (PERENNIAL) (Field Sow Thistle, creeping sow thistle): Fig. 49. Perennial sow thistle is a milkweed, 2 to 5 feet high, growing in dense patches. The leaves are more or less toothed and often the teeth look sharp and spiny, but they are rather soft and, compared with Canada and prairie thistles, they are relatively harmless. The flowers resemble those of the dandelion in size and shape. They are closed in bright sunlight. This perennial has many horizontal roots which send up new stems freely. The seeds are about ⅛ inch long, dull, dark reddish-brown, oblong, slightly flattened, ribed lengthwise and wrinkled transversely. They bear a tuft of reddish-brown hairs. The seeds are carried naturally by wind.

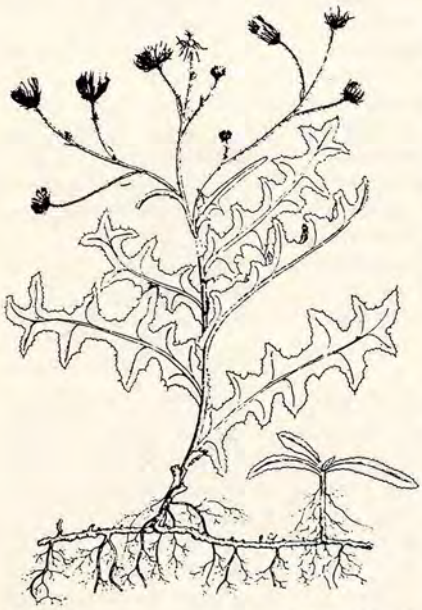


Fig. 49. Sow Thistle

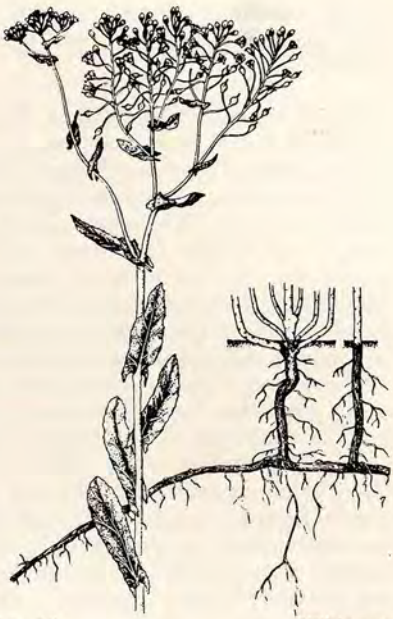


Fig. 50. Whitetop

There are two related weeds, common or annual sow thistle and annual prickly sow thistle. These are annuals, without horizontal roots, and have small flowers ¾ to 1 inch in diameter. The sow thistles belong to the chicory

family which is characterized by the presence of a milky juice and flowers like the dandelions.

● WHITE TOP (HOARY CRESS): Whitetop, Figure 50, is a member of the mustard family. Other common weeds belonging to this family are fan-weed, hares ear mustard, field mustard. White-top is an erect perennial, six inches to 2 feet in height. The leaves are 1½ to 3 inches long, irregularly toothed to almost entire length, grayish-green in color. The upper stem leaves are sessile while the basal leaves are more slender and narrowed into a short stalk. The flowering branches bear numerous showy, small inch in diameter. The plant in flower has a greenish-white to white flowers about ⅛ flat-topped appearance. The pod is somewhat heart-shaped, two-valved, and has a short persistent point at the apex. It often becomes prominently veined at maturity. The seeds are dark-reddish, brown, flattened and about the size of alfalfa seed, rounded at one end and narrowed to a point at the other. The seeds will remain viable in the soil for many years. The seeds are very difficult to separate from those of alfalfa or red clover. The root system consists of well developed horizonal roots, which spreads the plant horizontally and which penetrate vertically many feet. White-top seems to prefer slightly alkaline conditions, although it thrives under a variety of soil conditions. Wherever white-top becomes established it takes complete possession of the soil. Control of this weed is very difficult, and requires persistent effort.

Fig. 51. Wild Lettuce

● WILD LETTUCE; BLUE LETTUCE; SHOWY LETTUCE MILKWEED: A perennial milkweed, Fig. 51, growing in dense patches after it becomes well established. The stems are two to three feet high with smooth leaves covered with a thin white coating or bloom. Leaves variable, oblong to narrow in outline, lower ones often deeply cut, with segments turned backward; upper ones without a petiole and partly clasping the stem. The plant is filled with a bitter, milky juice. Flowers blue or purple, several to the plant about ¾ to 1 inch in diameter, shaped like those of a small dandelion. The plants produce many root

Stocks which extend horizontally underground and send up numerous shoots. In this way patches are formed so dense as to crowd out other vegetation.

The plants bloom in July and August. The seeds are about ¼ inch long, bottle shaped, red when immature, grayish to purplish when ripe, flattened, ridges running lengthwise down each face, making the whole seed look dull and purple. The tip of the seed bears a long white umbrella-like plume which is usually absent on seeds found in commercial grain.

Blue lettuce is propagated by seeds, by roots and by rootstocks. The plant is native to Montana. It is increasing rapidly in cultivated fields in nearly all parts of the state and it will continue to do so until a more determined effort is made to control it.

CONTROL OF BRUSH

Experiment shows that when the sage brush has been removed from the pasture or range the newly grown grass will support 128 head of cattle instead of 88. Beef production increases from forty three pounds to seventy seven pounds per acre. The government soil conservation program will contribute $1.50 per acre toward the eradication of sage brush. By adding another 75c to a dollar, depending upon current air-application costs in your area you can almost double the pasturage areas by utilizing the full productive possibilities of the land.

2,4-D attacks the sage and leaves the grass unharmed. Spraying will *not* kill all the sage but *will* do away with 75% to 80% of it. Mowing and grubing out the roots, as you have probably experienced, is not a practical method of eradication. Brush should be sprayed after it is well leafed out but before it becomes old and tough. Dr. L. M. Stahler of the United States Department of Agriculture at Brookings, South Dakota, says "I want to emphasize that you have yet barely touched your most unique field of spray operation. This is the application of herbicides for control of herbaceous and woody weed growth on pastures and range land.

Scattered throughout and uniformly over your field of operation there are millions of acres of rough pasture land not adapted to ground spray application of herbicide that could be economically improved by plane spray application of 2,4-D or 2,4,5-T. I am not thinking of the large acreage range areas now but of the average farm pasture and meadow. We have long ago shown that some of our most common northern pasture weed species such as ragweed, fleabane, marshelder, cocklebur, gumweed, can be satisfactorily controlled with applications of 2,4-D made at the proper time. Yet my observations indicate that there has been practically no change in the management of pas-

tures infested with these weeds and the average northern pasture is almost completely taken over by one or more of these species by mid-July each season.

A little demonstrational or missionary work on the part of air-applicators could easily establish the efficiency of spray application of 2,4-D for the control of these weeds.

Buckbrush, hazelbrush, prickly ash and other woody pasture weeds commonly found in uncultivated grazing areas in the northern one-half of this area, likewise, have been demonstrated to be efficiently controlled with proper application of 2,4-D or 2,4,5-T. The variation in species infesting pastures locally and the economics of control are factors that make aerial spraying of these species a local problem and business and one that can best be worked out and developed by the iniative of the local spray plane operator.

Sparked by the research and investigations of the Southern Great Plains Field Station at Woodward, Oklahoma, 100,000 acres of sage brush was treated in 1948, 330,000 in 1949. Application of herbicides for the control of sand sage is ideally suited to plane sprayers, as indicated by the fact that of the 1/3 million acres treated this year only 25,000 acres were treated with ground driven equipment. I should hasten to add that the sand sage area has only been touched as data indicate that Texas has 6,400,000 acres infested with this species, Oklahoma 600.000.

The investigations at the Southern Great Plains Field Station not only showed that sand sage could be controlled on range land with 2,4-D applied by plane but also showed this practice to be highly economical from the ranchers' viewpoint — data in 1948 indicating an increase in beef production of 40 pounds per acre where sand sage was controlled. When we have similar data to illustrate the efficiency and economy of control of other brush species the field of aerial spray application of herbicides will be tremendously increased." 172

● CONTROL OF BRUSH WITH 2,4,5-T:
Four conditions should be stressed for obtaining good results when using 2,4-D and 2,4,5-T for controlling undesirable plants; these are:

1. The plants should be in full leaf. Spraying should not be attempted after the first frost.
2. The entire leaf surface of the plants should be covered with a layer of the spray.
3. The plant should absorb the chemical into its system.
4. The temperature should be 70 F. or above and the chemical given time to dry on the plant before a rain shower.

The following plants show indications of complete control when sprayed according to the directions outlined above:

Alder	Elderberry	White Oak
Sweetfern	Smooth Sumac	Poison Ivy
Black Cherry	Choke Cherry	Hazel Nut
Arrowwood	Briers	Black Locust
Barberry	Red Maple	Thistle
Bird Cherry	Gray Dogwood	Hardhack
Tatarian Honeysuckle	Common Elm	White Pine (young)
Gray Birch	Quaking Aspen	Bush Honeysuckle
Black Birch	Pussy Willow	Wild Rose
		Apple

The following plants show some resistance to the effects of the spray, and at this date we cannot be certain of complete control on:

Ash	Cedar	Mountain Laurel
Red Oak	Nannyberry	Hickory
Juniper	Rock Maple	

● CONTROL OF SAND SAGE BRUSH WITH 2,4-D (Oklahoma recommendations):

RATE PER ACRE:

When April-May precipitation is normal or above, and plant growth is rapid — Use ¾ pound pure 2,4-D (acid equivalent) in form of *ester* in 3 gallons of diesel oil or in 2 gallons of water and 1 gallon of diesel oil,

Or, use 1 pound pure 2,4-D (acid equivalent) in form of *amine* or *sodium salt* in 2 to 4 gallons of water and 1 gallon diesel oil. Adding a detergent, such as Dreft, at the rate of one 11-oz. package per 100 gallons, increases the effectiveness of amine and sodium salts.

When April-May precipitation is below normal — Increase above rates one-fourth pound per acre.

TIME OF APPLICATION:

Spray only during month of May.

METHOD OF APPLICATION:

Planes should fly crosswind in swaths not more than 45 feet apart or 1½ times the boom width. Planes with long booms or roto-

sprays are preferred. Ground sprayers should operate crosswind at intervals no wider than the boom.

MECHANICAL AGITATION:

Use a mechanical agitator to emulsify all oil-water solutions to be used in airplane or ground sprayers. Use return-flow or other effective agitation in the plane.

DETERMINING DEGREE OF CONTROL:

Final kill of sagebrush and other perennial weeds cannot be determined until about 13 months after spraying. Determine percentage kill by counting and recording dead and alive plants in a narrow strip while walking across the sprayed area.

PRECAUTIONS:

2,4-D is not harmful to man, animals, or pasture grass (except in seedling stage of some grasses). Do not spray if there is likelihood of rain within 8 to 12 hours. Use precaution to avoid damage to susceptible crops.

Effective treatment of sand sagebrush plus wise grazing (deferment of grazing or light grazing for two successive summers) doubles returns from the land. Other brush and weed control practices can be expected to yield excellent returns.

Chemical control is cheaper, faster and more effective than mechanical control. Many range weeds and 80 per cent of sagebrush can be inexpensively killed with one proper application of 2,4-D. Solutions of 2,4,5-T are not effective on sand sagebrush.

Perennial broomweed (snakeweed, turpentine weed, etc.) and golden aster, which frequently infest hardland pastures, are easily killed with the same spray technique (formulation, date, rate), used on sand sage brush.

Control of prickly pear cactus and yucca (soapweed) appears promising with a wetting spray (¼ pint) of a 2% solution of 2,4,5,-T. Approximately 1 quart of 2,4,5-T (concentration of 3.3 pounds per gallon) in 4 gallons water and 1 gallon diesel oil, makes a 2% solution which can be applied in April, May or June to individual plants at a material cost of about 1% per plant. Further work is necessary before final recommendations can be made.

● SAGEBRUSH CONTROL WITH 2,4-D: As already stated, very excellent results have been obtained with 2,4-D on sagebrush in some areas. The less woody types are quite susceptible. For example, the sand sagebrush of the Great Plains area is not only killed easily but the stems deteriorate within a couple of years. 2,4-D acid is applied at the rate of one pound per acre.

The *big sage* of the northern great plains area can be killed only by complete coverage of the plant. Any branches not thoroughly covered by using plenty of oil, are said to continue to grow in a rather healthy state and even when the bush is killed, because of its tough and woody nature it will stand indefinitely on the range. It is still questionable whether it is economically possible to control this type of sagebrush. It must also be remembered that the sage is a source of emergency food for sheep and cattle and although not normally palatable is attractive to stock when no other food is available.

● BRUSH CONTROL WITH 2,4,5-T: For foliage sprays on brush applied with ground eguipment, high volume sprays are commonly employed to insure good coverage of all vegetation. In such applications, a 0.3% (as acid) spray concentration is adequate, and the amount per acre depends on brush density. Spray gallonage per acre may range from 40 gallons in thin brush to 300 gallons in dense growth. Airplane sprays normally apply from 2/3 to 5 pounds (as acid) in about 5 gallons of spray per acre. 159

● MIXED BRUSH 4 to 6 FEET HIGH: 2,4-D Ester Weed Killer 44 and 2,4,5-T Ester Brush Killer are formulated by Stauffer Chemical Company. This company recommends for the control of 4 to 6 foot brush the use of 1½ quarts of Stauffer 2,4-D Ester Weed Killer 44 and 1½ to 2 quarts of Stauffer 2,4,5-T Ester Brush Killer in 100 gallons of water per acre and wet the foliage thoroughly. 143

● MIXED BRUSH 8 to 10 FEET HIGH: 2,4-D Ester Weed Killer and 2,4,5-T Ester Brush Killer are formulated by Stauffer Chemical Company. This company recommends for the control of 8 to 10 foot brush the same proportion as recommended for 4 to 6 foot brush but apply 200 to 250 gallons per acre. The combination of 2,4-D Ester and 2,4,-5-T Ester may be applied in 50 gallons of diesel oil per acre on low growing brush and about 100 gallons per acre of the mixture should be used on tall brush. 143

● SHELL BRUSH KILLER 45: Shell Brushkiller 45 is a concentrated emulsifiable herbicide containing the isopropyl esters of 2,4-D and 2,-4,5-T. This product is used to kill woody and perennial plants such as alder, aspen, brambles, chokecherry, currant, gooseberry, wild grape, osage orange, poison ivy, poison oak, sassafras, wild cherry, willow and other susceptible plants growing in pastures, farm yards, fence rows, and along ditch banks, highways and rights-of-way, including power, telephone, and pipe lines and railroads. Best results from foliage sprays are obtained when plants are in full leaf and actively growing. On brambles, apply when new shoots are at least 12 to 14 inches high. For airplane application, use 3 to 4 quarts in 10 to 15 of Shell Weed-killer 20 or diesel fuel oil and apply at 10 to 15 gallons per acre.

Emulsify the concentrate with an equal quantity of water by agitating or circulating through the pump and back into the tank, then

add more water to dilute mixture to proper strength. Maintain agitation until the tank is empty. Dilutions with oil are made by simple mixing. 146

BRUSH SUSCEPTIBLE TO 2,4-D

Alder	Hornbeam	Scotch Broom
Apple	Horse Chestnut	Shadbrush
Aspen	Juneberry	Silverberry
Barberry x	Juniper x	Skunkbush
Birch	Larch	Mulberry
Blackberry	Licorice	New Jersey Tea
Black Locust	Maple	Spicebush
Box Elder	Moonseed	Wild Rose
Cherokee Rose	Elderberry	Sweet Gum
Cherry	Elm	Witchhazel
Chestnut	Fir	Trumpet Vine
Chinaberry	Oak x	Tung
Cottonwood	Osage Orange x	Poplar
Currant	Paw Paw	Prickly Ash
Dewberry x	Pear	Wild Plum
Dogwood x	Pecan	Sweetfern
Gooseberry	Pine	Winterberry
Greenbrier x	Poison Ivy (sunlight)	Tree of Heaven
Grape	Poison Ivy x (shade)	Wormwood
Hackberry	Poison Oak	Virginia Creeper
Hawthorn x	Hercules Club	Snowberry x
Hazel	Hickory x	Soapweed
Hazelnut	Honey Locust	Sumac
Hemlock x	Raspberry	Willow
Buckbrush	Sage brush	Sycamore
Buckeye	Salt Cedar	Wolfberry
Catalpa	Sand Plum	Tulip Tree
Honeysuckle	Sassafras	Wahoo
		Walnut 77

BRUSH RESISTANT TO 2,4-D

Ash	Basswood	Beech
Holly	Laurel	Maple, red
Mesquite	Persimmon	Rhododendron 77
Spruce		

WATER WEEDS

Little has been done on control of weeds in irrigation and drainage ditches. Usually the water is shut off and the weeds cut out, burned or grubbed out. In some cases, shading can be used to advantage. This is a slow expensive process.

Emergent plants such as tules, cattails, watercress, etc., often become so bad that a drag-line or other machine must be used to clean out the waterways. Some success has been obtained in killing cattails and tules with 2,4-D and sodium chlorate. The spray has been made more effective by adding three gallons of diesel oil to each 100 gallons of spray. The same problem of the effect of the water on crops must be determined. Chemical control of submergent water weeds is in its infancy yet holds great promise in light of recent work. Copper sulfate at 8 1/3 pounds per million gallons of water has killed Algae, Chara and water weed according to some authorities. Temperature, speed of flow, alkalinity of the water—all affect the success of the treatment. *Caution:* keep livestock away from ditches near points of application.

A chlorinated hydrocarbon known as Benoclor 3-C has recently proven very helpful in control of submergent weeds. In the use of this material first reduce the flow of water to a minimum allowing just enough water to cover the weeds and at the same time adjust the flow to ¾ to one foot per second. Then inject the Benoclor 3-C into the water. A nozzle with 20 to 40 thousandths inch opening is advisable. The material should be put into the water at 60 pounds pressure and the nozzle should be 4 inches under the surface. Benoclor 3-C material losses a good deal of its effectiveness in about 1½ miles and additional material must be added at this point.

It is the usual procedure to put 2/3 of the Benoclor in the ditch at the starting point of the treatment, 1/6 at 1½ miles from this point and another 1/6 at a point three miles from the first point. This should clear five miles of ditch. The operation must then be started anew. It is necessary to wait at the second and third points until the material reaches those points from above. Since the material forms a white milky cloud it is easy to tell where it is in the canal. No definite recommendations can be made, but if the ditch surface is 10 feet wide, the velocity ¾ foot per second and infestation 100 per cent then 12 gallons of Benoclor 3-C are needed per mile. This might be a figure from which to work.

Benoclor 3-C will kill fish and other animal life present in the canals. 121

Cattails

The Bureau of Reclamation has been interested in control of cattails and had good success during the past summer in effecting kills by using 1½ pounds of 2,4-D parent acid and ¾ pounds of ammonium sulfamate in 200 gallons of water applied per acre. Checks will have to be made this spring to determine the amount of permanent killing. 121

● ACQUATIC WEED KILLERS: Effective results may be obtained from:

(a) Trichlorobenzene.
(b) Orthodichlorobenzene.
(c) Petroleum solvents.
(d) 2,4-D is effective against tules but not quite as effective against
(d) cattails, Scotch bloom is very susceptible to 2,4-D.

The best result on acreages of tules (Nevada) has been with plane application of 15 gallons per acre, composed of three pounds of 2,4-D acid, and two quarts of summer oil. Reported at the 1949 Western Weed Conference. 225

POISONOUS WEEDS

Reported at 1949 Western Weed Conference (Washington State Report) were the following poisonous weeds in the state: Tarweed, water hemlock, poison hemlock, jimson weed, low lockspur, foxglove, henbane, creeping buttercup, poison ivy, poison oak, cocklebur, death camas, and tall lockspur. 225 Nevada reported at the 1949 Weed Conference that test plots of *halogeton* continue to show straight fuel oil and emulsions, and 2,4-D in oil to be the best spray materials. 2 pounds of 2,4-D in water with ½ gallon of summer oil to 50 gallons of mix is giving promising results. 225

2,4-D

A comprehensive description of most of the agricultural chemicals appears in Volume One. However, because of 2,4-D as a weed killer a further discussion of its use with weeds is included in this volume.

2,4-D will kill most species of *Broadleaved annual weeds*. Many are highly sensitive to 2,4-D and kill easily. Others are only moderately sensitive, but can be killed. Only a few species can withstand repeated applications of the chemical.

● BIENNIAL AND PERENNIAL WEEDS: (plants with roots that live more than 1 year) vary widely in their reaction to 2,4-D. A few perennials, including dandelion and plantain, can be killed with one treatment. Curly dock and other weeds with taproots are harder to kill. 2,4-D usually kills the foliage on perennials that have creeping roots, such as bindweed and canada thistle, but repeated spraying of the new growth may be needed to kill all the roots. Detailed control directions can be obtained from a county agent, the State agricultural college, or the United States Department of Agriculture.

2,4-D sprayed on the leaves will kill foliage on many species of *woody vines, shrubs, and trees* and on some of the young woody tissue. A few species will die back to the ground, and the roots will be damaged. Woody plants can sometimes be killed by cutting the stems close to the ground and applying concentrated mixtures of 2, 4-D to the fresh cut; it is generally best first to mow them and then spray the new growth with 2,4-D when the sprouts are 12 to 18 inches high.

The *crop plants* react differently to 2,4-D, just as do weeds. Grasses are generally resistant, and broadleaved plants usually susceptible. Garden vegetables and flowers, almost without exception, are highly sensitive, and no plant is entirely immune. Even crop plants considered tolerant, especially young plants, may be injured severely by an overdose. Since grasses generally are highly resistant, weeds can be killed or controlled with 2,4-D spray without injury to lawns, pastures, small grain, and cornfields.

The effect of 2,4-D on crop plants is governed by the chemical form used, the stage and vigor of plant growth, and differences in susceptibility within species. Seedlings of some plants, as annual sunflower and cocklebur, are so sensitive that all can be killed on an acre of ground with as little as a quarter of a pound of 2,4-D acid. As they approach maturity, killing is more difficult. Different corn hybrids have been found to vary from susceptibile to resistant. Flax is generally sensitive, but the range of reaction between commercial varieties is wide. There are differences in susceptibility within species of field bindweed, Canada thistle, and other weeds. Resistant plants and plants treated during an inactive stage of growth react more readily to the ester forms of 2,4-D.

The dosage for spraying weeds in growing crops depends on what the crops will stand. A compromise between crop injury and effective weed control may have to do. Weeds can sometimes be controlled satisfactorily without being killed. Those that are stunted offer less competition to crop plants for moisture and food. Given a chance to get ahead, some crops will suppress the weeds. 62

Although a large amount of experiment has been done on the effects of 2,4-D on weeds, we still do not know how it kills them. Contrary

to earlier beliefs, weeds do not grow themselves to death. 2,4-D acts on the entire plant system, moving through all or part of the plant.

Any treatment strong enough to kill weeds will do some injury to any grain crop. When the treatment destroys the weeds its crops net benefit is enough to give increased yields. The objective in weed control is to give the maximum weed kill with the minimum crop injury.

● WEEDS ARE QUICKLY DISTORTED BUT SLOW TO DIE: In warm weather, the reaction of weeds to 2,4-D can usually be seen within 24 hours. Weeds are not killed in that period, nor are they discolored or burned, but the stems and foliage curl and after a few days the tissues usually become crisp and crack easily when bent. Later, there may be some slight yellowing or other color changes. Death comes in from three weeks to a month or more, depending upon:

1 The strength of the solution used.

2. The amount applied.

3. The rate of growth and maturity of the tissue.

4. The air temperature.

5. The amount of moisture in the soil.

6. The specific character of the plant itself.

On a bright, warm, dry summer day, from three to four weeks after the date of spraying, the weeds may dry so fast that nothing but a few shrivelled and dried leaves can be seen. The leaves virtually disappear while you watch them. 210

Factors in 2,4-D Effectiveness

1. Weeds have varieties just as other plants—some are less susceptible to 2,4-D than others.

2. Plants growing in sandy soils seem to show greater susceptibility to 2,4-D.

3. A rain immediately after treatment lessens the effectiveness of the treatment. A heavy rain 24 hours after treatment is beneficial as it starts the ground leeching process.

4. Soil moisture is important. Irrigated land gives better results than dry land. Sub-irrigated produces best results. Surface irrigated land should be irrigated immediately after treatment.

5. Temperatures between 60 and 90 are best for 2,4-D treatment. Tops of plants are killed down faster but the final effect on the plant is the same.

6. Treatment should be made at the time perennial weeds reach their maximum emergence but before viable seeds have developed.

7. The type of 2,4-D (acids, esters, salts) may have advantages over each other under certain conditions but no certain evidence is yet available.

8. 2,4-D is slow acting—on easily killed plants twisting and bending of leaves and stems may be noticed in a day or two. On more resistant plants up to 3 to 4 weeks may be required before they are killed.

9. Rate of vigor or growth is more important than stage of growth in effect of 2,4-D on plants treated. Plants growing in the shade are harder to kill.

10. Low temperatures following treatment with 2,4-D may slow down the kill of weeds but will likely not affect the final kill.

11. The amount of water used per acre in applying 2,4-D is of no particular importance providing enough is used to get even distribution. 5 to 10 gallons per acre are generally used. 181

Measuring the Amount of Kill

2,4-D usually acts much more slowly than other weed killers. It causes twisting, bending, coiling of the stems and yellowing of the leaves within a few days after application. This does not, however indicate the measure of kill. Only the plants that actually die should be counted. The count should be made about six weeks after the treatment. For perennial plants, only the amount of regrowth that occurs the next year is a fair measure of the results of the treatment.

Where wheat, barley and oats are treated with an application rate high enough to give a ninety percent kill of the weeds you can expect a 5 to 15 per cent reduction in crop yield. The net yield increase, however, may be large in view of the fact that serious weed competition would have reduced the yield up to 50 per cent had no treatment been given the crop.

● COMPARISON OF SALT, AMINE AND ESTER FORMULATIONS: The 2,4-D acid is highly insoluble in water. As a result, the acid has to be chemically reacted with various compounds so that it can be used effectively. The main classes in which 2,4-D is marketed are:

1. The metallic salts of which ammonium and sodium are the most common.

2. The amine salts of which triethanolamine is the most common.

3. The ester formulations which are usually marketed as ethyl, iso-

propyl or butyl ester of 2,4-D. Generally metallic salts are powders and the amines and esters are liquids. The esters, amines, and metallic salts however can be purchased as dusts.

2,4-D salt, amine and ester formulations act differently when applied on plants. All brands of the ester group act quickly; the amines are slower and metallic salts still slower. The various formulations of esters and amines do not vary a great deal in effectiveness on young vigerously growing, susceptible annual weeds. On most perennials, and on older or more resistant annuals, the difference in ability to damage plants is very evident. Similarly overdoses or improper application of esters are more apt to damage crops than the amines or salts.

Esters, largely because they have on oily base, are absorbed into plants most rapidly and are not as likely to be washed off by rain as amines or salts. The amine salts will be absorbed more rapidly than the metalic salts. Metallic salts which come as a powder are soluable in water. However, sprayers without agitators have difficulty getting the powder completely into solution. The amines and metallic salts are soluble in water but not in oil. The esters are soluble in oil and emulsify or mix readily in water. 178

● RATE OF APPLICATION FOR NON-SELECTIVE WEED KILLING: Ragweed is quite susceptible to 2,4-D treatment. 2 pounds per acre of pure 2,4-D or equivalent is generally sufficient for good results for this and other sensitive weeds. (See Book Three "Methods of Application" for information on computing acid equivalents).

For weeds not so susceptible, such as bindweed or morning glory, white top, tansy, Canada thistle, willows, and perennial sow thistle, 2 or 3 pounds per acre may be used. Rates of less than ½ pound per acre frequently do not kill many weeds. It merely stunts them giving the crop the advantage. These extremely low rates which merely stunt the growth are not economical. The stunted weeds usually recover and produce seeds.

There are dozens of commercial formulations of 2,4-D all of which are effective for the specific purposes for which they are designed. Typical of these commercial formulations are *Shell Weedkiller 60* Amine by Shell Oil Company and *Weedone Concentrate 48 by* American Chemical Paint Company.

Shell Weedkiller 60 Amine is a highly concentrated liquid alkanol amine salt of the enthanol and ispropanol series of 2,4-D containing 4 pounds of 2,4-dichlorophenoxyacetic acid per gallon. It is soluble in either soft or hard water and can be mixed in any desired strength in water. Shell Weedkiller 60 Amine is for use as a diluted spray in the selective weeding of grains, flax, rice, corn, sugar cane, and for the control of many kinds of acquatic weeds, broad-leaved weeds, and woody shrubs. 2,4-D kills by disruption of the growth process of the

plant. Grasses are quite resistant. The amine salts are formulated especially for low-gallonage applications—10 gallons or less per acre. 158

"Weedone Concentrate 48 is the concentrated ethyl ester formulation of 2,4-D the original ester that has had more years of field use than any other 2,4-D weedkiller. Containing 3 pounds 2,4-D acid equivalent per gallon with special wetting and penetrating agents.

Weedone Concentrate 48 is consistently more effective than salt formulation in treating perennial weeds and annuals in late stages of growth, during dry weather, and under other adverse conditions. It sticks rain or shine. Mixes with oil for ideal airplane application. Can be mixed with any amount of water for high or low volume application. Requires lower amounts of acid per acre for equal results." 76

Weedar 64 is a concentrated liquid akanolamine salt formulation of 2,4-D. Contains 4 pounds of 2,4-D acid equivalent per gallon. Weedar 64 is completely soluble in water. Will not clog nozzles. Easier on crops than ester formulations. Will not injure adjoining crops except in case of drift. Particularly useful for treating weeds in crops near such susceptible plants as cotton, tomatoes, peas, tobacco or valuable ornamentals, and for treating small annual weeds that are growing actively.

Repeated Top Killing Method

Weeds can be starved to death by repeated top killing. The question is whether it is economically sound to attempt eradication by the repeat treatment method. Sixty to ninety days must elapse between the treatments in order to get sufficient regrowth for the second application. Two treatments, therefore, are the maximum possible for a single growing season.

● TEMPORARY SOIL STERILITY: 2,4-D causes a certain amount of temporary soil sterility. You will want to be aware of the several factors which are known to effect soil sterility.

Soil sterility is dependent upon the rate of application, the weather, the soil type and the amount of organic matter in the soil. Plenty of moisture will provide a good leeching process and high soil temperature with plenty of moisture will provide a good vacteria action. Four to eight weeks is the normal period for soil sterility following treatment. Dry, cold weather can cause sterility to prolong even into the next growing season.

OTHER WEED KILLING CHEMICALS

Previous paragraphs have covered the use of 2,4-D. The following paragraphs enlarge upon the use of certain of the other chemicals adaptable to the non-broadleaf weeds and the grasses.

Dinitros

The greatest use of the dinitro selectives has been to kill wild mustard, radish, fiddleneck, and other broad-leaved weeds in wheat, barley, and oats. With development of 2,4-D much of this selective control is being done with that material.

The California Experiment Station at Davis has conducted tests on the two main dinitro compounds—sodium dinitro-ortho-cresylate and the ammonium salt of dinitro-ortho-secondary-butyl-phenol. The first is sold under the commercial name Sinox; the second, as Dow Selective and as Sinox W. These and other dinitro selectives may become available under other trade names in the future.

Sinox W. and Dow Selective, being liquids, are more convenient to handle than is Sinox, and they are somewhat more selective on weeds in peas, young alfalfa, vetch, and other legumes. These crops seem to have better chemical tolerance for the ammonium dinitro-butyl-phenylate than for the sodium dinitro-cresylate. However, the latter is preferred by some for weed control in flax and onions.

One weakness of the dinitro sprays is the fact that they will not kill weedy grasses. These may, however, be controlled by general contact and fortified oil emulsion sprays if the sprays are applied so that leaves of such crops as onions, corn, milo, cotton, etc., are not touched. Some of the dinitros have been applied on a limited scale as dusts, but such applications seem to be less effective than sprays.

● SINOX: Sinox is a slurry (watery mixture) of sodium dinitro-ortho-cresylate. Dilute the necessary amount of Sinox with water to the total volume required to wet the vegetation—usually 50-120 gallons per acre, depending on the size of the plants. Partially fill the spray tank with water. Add the Sinox. Use an agitator in the tank, as this makes the Sinox mix more rapidly. Add the remainder of the water, with the agitator still running. Then add 3 pounds of either ammonium sulfate or aluminum sulfate for each gallon of Sinox used. Agitate this thoroughly, and spray is ready for use.

Until the discovery of 2,4-D Sinox an organic dyestuff sodium dinitro-orthocresylate formulated by Dow Chemical Company was probably one of the most used selective herbicides. It is yellowish powder or paste not too readily dissolved in water. For best results the weeds should be in the seedling stage, the temperature should be above 70°F. and the weather should be sunny and rain should not fall for 24 to 48 hours. More recently Sinox-D a dust used at the rate of three pounds per 100 gallons of water has almost replaced the older paste form of Sinox.

Dosage range from one gallon of stock solution to 20 gallons dissolved in 100 gallons of water applied to the acre. The dosage depends

upon the resistance of the crop and the weed to be controlled. Radish is killed by 1½ gallons per acre, and mustards one gallon. This gives an idea as to relative susceptibility of a few species. As for crop plants flax is injured if more than 1¼ gallons of the stock is used, onions 2 2/3 gallons; corn 1½ to three gallons; and barley ten gallons.

Sometimes an activator or spreader such as diesel oil or ammonium sulfate greatly increases the toxicity of Sinox—A few pounds in 100 gallons of water is sufficient. By increasing the amount of the activator or spreader, Sinox sprays can become a contact herbicide used to kill the top growth on most grasses and broadleaved species. 121

● DOW SELECTIVE AND SINOX W.: In using Sinox, remember that the chemical in its original container is not completely in solution. Be sure that the container is completely emptied.

The active ingredient in these preparations is the ammonium salt of dinitro-ortho-secondary-butyl-phenol. Since this chemical is approximately three times as toxic as sodium dinitro cresylate, less is required in the spray mix.

Preparation: Add the concentrate to sufficient water to treat one acre. Since the spray concentrate is in liquid form, only enough agitation to insure a uniform solution is required. If the concentrate is added to the tank during filling, the solution will be ready for use when the tank is full. No ammonium sulfate need be added. Dosage: From 3 to 6 quarts per acre, the amount depending on the weed and the crop growth and the crop's tolerance. During dry, sunny weather more chemical is required than during cloudy, moist weather. For airplane application, the common rate is 3 quarts in 15 to 20 gallons of water, per acre. Although this dosage on flax results in slightly burning, it is commonly used.

Use of dinitro selectives on peas is becoming standard practice. Temperature is an important factor in spraying peas. Experiments in the Northwest have resulted in the following recommendations for adjusting the dosage: 60 degrees—65 degrees F. 4 quarts; 65 degrees—70 degrees F. 3½ quarts; 70 degrees—75 degrees F. 3 quarts; 75 degrees—80 degrees F., 2½ quarts. These recommendations are for ground-rig application of 100 gallons per acre at 35 to 50 pounds pressure.

For application of dinitros by ground rig, 4 quarts in 50 to 80 gallons of water, per acre, are used. On flax, this usually results in slight burning, but generally gives good weed control. Crop plants growing in alkali soil or poorly drained areas generally suffer more damage than do healthy, vigorous plants.

Sulfuric Acid

Dilute sulfuric acid is being used more and more each year for the control of broad leafed annual weeds in grain fields.

Plants affected: Wild mustard, wild radish, yellow star thistle, asparagus, sugar beets and onions. *Application:* Application of a 10 to 12 per cent solution at the rate of 125 gallons per acre has been exceedingly effective in the control of wild mustard and radish in the grain.

The spraying should be done in early spring. Often fields are too wet to get into with surface equipment, which fact makes *Air- Application* most practical. Ground costs of acid spraying is 3 to 4 dollars per acre.

IPC

IPC is being used to control winter annuals and bunch grasses in ladino clover and alfalfa pastures. It is used at rates of from 2 to 5 pounds per acre, and must be applied so that it can be washed into the soil by rains or irrigation water. Absorbed from the soil, it kills grasses at concentrations that do not seriously injure the pasture crops.

This chemical is not very soluble in water. Some commercial preparations come in the form of wettable powders, others, as emulsion concentrates. These may be applied in suspension in water, if sufficient water is used, if the suspension is kept well agitated, and if the spray pressure is around 100 pounds. Do not attempt low-volume application of the suspension. 5 The chemical should be present when the seed germinates. It is not recommended for control of perennial grasses and broad-leaved weeds. 165

Cyanamid

Granular forms and dusting grades of cyanamid are effective on small annual weeds and grasses in some crops such as asparagus and onions. Usually these materials are applied at approximately 400 pounds per acre, divided into two or three applications. The material is under trial at the present time. Liquid forms are being tested to discover their possible use as specific weed killers. When the price is lower they may be used on large areas, possibly in corn and small grain, as well as on some vegetables. 166

KNOW YOUR WEEDS

PART THREE

FUNGUS IDENTIFICATION

See earlier dicsussion of Fungus in Volume One. The most common fungi are: Brown rot, Downy mildew, Leaf spot, Peach leaf curl, powdery mildew, stem rust, Curly top and anthracnose.

Stem Rust - Barberry

Stem rust is caused by a fungus that lives in the northern states on certain kinds of barberry bushes and grains and on many wild grasses. The rust is spread from one host plant to another by spores that are carried by the wind.

This rust lives through the winter in the form of black spores on wild grasses, grain stubble, and in straw piles. In the early spring the black spores germinate and produce a new crop of spores which are carried by the wind to the barberry bushes. On these bushes the new spores produce cluster cups. These cups contain the spring spores, which can infect wild grasses and grain plants near-by. On wild grasses and grains the destructive red stage, known also as the summer stage, develops.

During the rest of the season the rust develops independently of the barberry. Several generations of spores are produced on the grains and grasses before they mature. By means of these spores, rust spreads from plant to plant and from field to field, sometimes taking in large areas, for each spore is capable of infecting another plant.

As the grain and grasses mature, the black spores form on the stems. These spores are carried through the winter to start another cycle of infection in the spring. Thus the life cycle of this rust fungus in the North-Central states, Fig. 52, depends on the barberry. When the rust spreading barberry is destroyed, stem rust cannot live here from one season to the next. And until it is destroyed, farmers in this important grain-growing region will continue to suffer losses that they could avoid.

The development of stem rust and the amount of damage it does depends on the growth of the crop and the weather. The less mature the crop is when rust hits it, the greater the damage. Warm, muggy weather favors the development of rust. Dry weather and low temperatures hold it back. Infection starts when moisture and temperature are favorable for the germination of the spores. Even under the most favorable conditions, however, there can be no stem rust unless the spores of the fungus are present. 198

● IDENTIFICATION OF BARBERRY: The barberry that harbors and spreads stem rust is easy to tell from the harmless varieties. It is a tall thorny plant with many canes, Fig. 52. In shape it resembles the well known spiret, honeysuckle, and mock orange. It may be of any height up to 12 feet, depending on its age.

The leaves of the rust-spreading barberry are oval and have fine saw-toothed edges. They grow in clusters on the stems and may be either green or purple. The thorns grow either 3 or 5 in a place. The

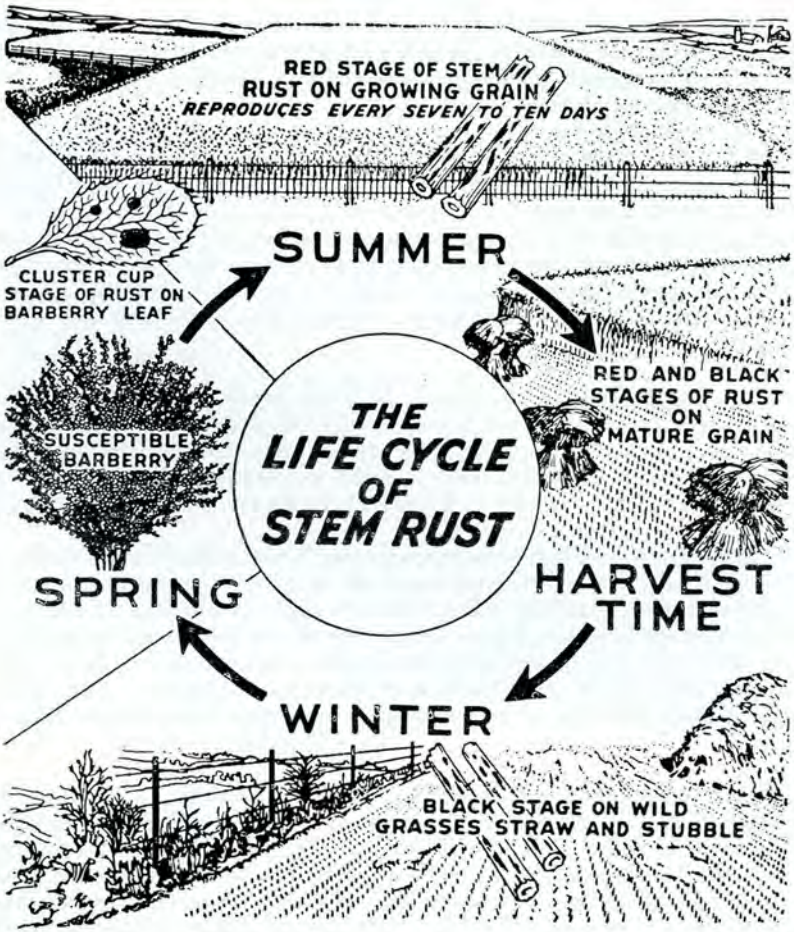


Fig. 52. Courtesy University of Illinois, College of Agriculture
Life Cycle of Barberry Spreading Rust

flowers grow in clusters and are yellow. The berries grow in bunches like currants and turn bright red in the fall. The outer bark is gray, the inner bark bright yellow.

Apple Powdery Mildew

For apple powdery mildew, apply a pink spray when cluster buds have seperated. Two and one-half per cent lime-sulfur can be used on Jonathans and Romes. Apple powdery mildew is seldom injurious to Delicious and Winesaps. Lime-sulfur also controls blister mites. Do *not* spray Delicious with lime-sulfur in the pink or calyx stage, as a severe fruit drop may occur later.

You can spray Bartletts with 2 per cent lime-sulfur in the pink to control mildew, blister mite, and European red mite. It is suggested that the pink spray on Anjous be limited to 1 per cent lime-sulfur plus 4 pounds wettable sulfur or 1½ pounds of *fermate* to 100 gallons for pear scab.

Two per cent lime-sulfur can also be applied in the calyx period to control mildew and scab *provided it has been already used in the pink spray*. Delicious with 1½ pounds of *fermate* per 100 gallons for scab. Reduce calyx sprays for pears in strength to 1 per cent lime-sulfur plus 4 pounds wettable sulfur for mildew or 1½ pounds of *fermate* to 100 gallons for scab.

Powdery Mildew on Peaches

A white or buff-colored fuzz or downy growth starts on the leaves in early summer. The leaves crinkle or curl to some extent and fall in summer if heavily molded. The twigs, if they are severely injured, become curled and stunted. Young fruits become covered with a mold. Large patches of white or, later buff circular to irregular areas cover the surface. The flesh of the fruit hardens, cracks, and the fruit may be badly shaped, stunted, and drop early.

This mold overwinters in the buds and comes out into the leaves in the spring. It does not become noticable until late spring or early summer. The disease is favored by closely planted orchards and by heavy irrigation. Most of the commercial varieties are more or less susceptible. Gold medal, however, is reported particularly susceptible.[58]

Anthracnose

The disease requires moist weather, and hence, in the western cotton growing states is of no importance; but in the eastern states it usually is responsible for serious seed rot in soil, seedling damping-off, and boll rot.

For control of anthracnose the use of 2 or 3 year old seed is of an advantage. Seed saved from the run of cotton picked in dry weather, throughly dried, and stored in a dry place, is good after 3 or 4 years of storage; most of the fungus is dead even on 16-month-old seed. Seed produced in the dry west usually is free from the fungus because the disease there is very uncommon. In any case, treat the seed with New Improved Ceresan, 1 ounce per bushel, to protect it against soil rot caused by other fungi than anthracnose. 201

Powdery Mildew of Cherries

The disease is not often serious on cherries, but it does occur in some seasons, even causing injury to the fruit. The white felt or mold starts on the leaves in late spring but may not become really abundant untill near harvest or often after harvest. The mildew is not as plush or downy as on peaches but the mold is more of a thin white coating on the top of the leaves or fruit. Later the tiny black bodies form in the mold. The spots then appear dirty gray. 58

Use *fermate* 1½ pounds per 100 gallons plus 2 pounds wettable sulfur *after* harvest to check the disease. In the eastern United States, dusting with sulfur (for dusting by airplane, try 60-80 pounds per acre) as soon as the disease appears or about shuck fall has been successful. The residue problem must be considered. Most local complaints about cherry mildew, however, have come after harvest. 58.

Downy Mildew

Downy mildew is especially prevalent in the alfalfa-growing regions of the Pacific Northwest. As this fungus is systemic within the plant after initial infection, it maintains itself from year to year with ease, and infection is general if environmental conditions are favorable for its development and spread. Conditions that favor mildew are warm, humid weather. 114

Brown Rot (Phytothora Fruit Rot)

During wet seasons, such as that of 1948, brown rot is important on the fruits in some places. Fruit affected with brown rot may show brown soft areas before maturity or at ripening. The fruit becomes covered with tufts of the gray mold. Later the fruit shrivels and falls, or it may cling to the tree as a mummy. 58

Leaf Spot

Leaf spot occurs in all regions where alfalfa is grown. As this fungus is dependent upon suitable environmental conditions for rapid de-

velopment and spread, however, it is more frequently found in regions that have warm humid weather during the summer months. Leaf spot often is severe enough to defoliate plants to such an extent that the hay crop is worthless. Leaf blotch is very similar in its distribution and habits to leaf spot, and its effect on the alfalfa plant is of the same nature. 114

Peach Leaf Curl

Leaf curl appears in early spring when the leaves unfold. The leaves become thickened, puckered, twisted, curled, malformed, and brittle. They are yellow to red or mottled in color. Once recognized, the thick, brittle, brightly colored leaves cannot be mistaken for any other trouble. The fungus is carried over from one season to the next on the buds and bark of branches or, probably, in the soil. 58

Curly Top

Curly top disease is one of the most destructive of all virus diseases affecting sugar beets, beans, tomatoes, spinach, swiss chard, melon and flowers. The virus of curly top survives the winter in both the beet leaf-hopper and in its host plants. It is transmitted by the leaf-hopper from its host plants of other weed hosts and cultivated susceptible crops during the spring movement of the leafhoppers. Some of these crops in their seedling stage are very susceptible to curly top disease and infected plants often die. The young plants are most susceptible.

● CURLY-TOP IN TOMATOES: On tomatoes, the disease is known as Western Yellow Blight. The name "Yellows" is sometimes, but not widly, used. This disease was known on tomatoes for more than thirty years before its connection with curly top on beets was found. It appears on tomato plants of any age, and young plants are often killed outright. When an older plant is attacked, growth ceases, the leaflets roll upward, become leathery, and turn yellow. The veins of the leaves may become purplish as the first sign or symptoms appear. The small fruits turn yellowish-red, and the whole plant slowly dies.

There is always a space of some days from the time a beet leafhopper, carrying the curly-top virus feeds on the healthy tomato plant and the time when the disease appears. However, because high temperatures cause the symptoms to develop more rapidly. the disease may suddenly appear on many plants in a field after a few days of hot weather. This often leads growers to think that curly top is caused by hot weather or hot winds.

PART FOUR

RESIDUES

On plant products intended for human or animal consumption, the amount of certain insecticides remaining at harvest time is of legal importance. Laws have been passed and enforced regarding several of these materials on food for human use.

Definite limits are set for arsenic, lead, and fluorine. These limits or "tolerances" (as of 1942-1943) are 0.02 grain of arsenic as arsenious oxide per pound, 0.025 grain of lead pound, and 0.02 grain of fluorine per pound. Two courses are open to avoid condemnation of produce on account of residue. It may be washed or otherwise cleaned before selling, or the use of these insecticides may be avoided for as long an interval before harvesting as possible. The latter is by far the cheaper method and should be used whenever possible. Thus in most states lead arsenate is recommended for codling-moth control only in the early spray applications; oil and nicotine or other fixed-nicotine sprays being used later in the season.

Even the avoidance of lead-arsenate spray for several weeks before harvest does not ensure a low residue on fruit in districts where heavy early applications are needed, and wiping or washing is therefore necessary. For large quantities of fruit, the use of commercial machines is the only way that is practical. A washing fluid containing 1 per cent commercial hydrochloric acid is perhaps most widely used. At 70°F. this will bring fruit below the tolerances unless excessive wax has formed or oil sprays have held much lead arsenate on the fruit, when higher temperatures or an alkaline wash is necessary. Most alkaline washes, however, although they remove arsenic efficiently, leave much of the lead; and they impair the keeping quality of fruit. 60

Removal of Residue From Fruits

The Federal Food and Drug Administration 43 in its discussion of fluorine residues says this about spray residue removal: "The amount of fluorine in spray residue remaining on apples and pears at the time of harvest increases with the number of fluorine sprays used, the decreasing length of time elapsing between the last of such sprays and harvest, and the use of substances which cause greater adherence of the spray to the fruit.

The proportion of fluorine remaining on apples ranges from a few milligram per kilogram to over 50 milligrams per kilogram. (One milligram per kilogram is approximately equivalent to .007 grain per pound.) It is possible, therefore, for one fruit to bear more than 7 milli-

grams of fluorine. The spray residue remains on the surface of the fruit and most of it can be removed by washing processes in common use in the industry. One process uses only one washing and rinsing operation. In such process dilute hydrochloric acid is used as the washing solution. This process is efficient in removing spray residues from apples and pears grown under light spray schedules.

In another process two washing and rinsing operations are used. In this process the fruit is first washed in sodium silicate or soda ash solution and then in a dilute hydrochloric acid solution. This process is efficient in removing spray residues from such fruits grown under a heavy spray schedule or when oils and stickers are added to the spray material, or when the spraying is continued late into the growing season.

In both washing processes the spray residue is removed more effectively when the washing solutions are heated, however, the heating of the solutions tends to cause injury to the fruit which increases as the heat is increased. When the solutions are not heated to over 100 F. the amount of injury to the fruit is not material. The washing processes for apples are at least equally effective for pears. Efficient washing usually removes spray residue to such extent that the fluorine remaining on apples and pears is about 5 milligrams or less per kilogram without risk of excessive injury to the fruit. It can be reduced in practically all lots to 7 milligrams per kilogram without such risk.

● RESEARCH ORDERED BY CONGRESS: Congress in 1950 appropriated $50,000 to the U. S. Department of Agriculture for the purpose of determining the possible effect of spray residue on consumers of fruits and vegetables. The U. S. Department of Agriculture in turn has contracted with the U. S. Public Health Service to do this research. 215

● SPRAY RESIDUE HEARING IN PROGRESS: At the time this edition went to press the spray residue hearings held under the direction of Bernard D. Levinson, Examiner for Food and Drug Administration, were in recess.

It appears that the results of the newly instigated research program of the U. S. Department of Agriculture would not be available for study by the Food and Drug Administration in time for their final hearings on the subject. It is possible, however, that the Food and Drug Administration will delay their findings until the results of the research being conducted by the U. S. Public Health Department are available.

The Problem of Residues

Cryolite, calcium arsenate, DDT, DDD, and benzene hexachloride leave poison residue which remain on the plant long after application. If any of these have been applied to edible portions of plants (such as

tomatoes), carefully wipe, wash or peel before serving. On cauliflower, cabbage, lettuce, and similar vegetables do not use any of these materials after the heads have begun to form. On leafy vegetables that do not head, don't apply materials after the first month to six weeks of growth.

On beans, peas, squash, cucumbers, and similar vegetables, do not apply after the fruit is set. At the date of this publication the amount of spray residue permitted by the Food and Drug administration on apples and pears is:

ARSENIC	0.025 grains per pound of fruit (3½ p.p.m.)
LEAD	0.05 grains per pound of fruit (7 p.p.m.)
DDT	0.05 grains per pound of fruit (7 p.p.m.) 58

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