INSECTS
THAT ATTACK WHEAT IN KANSAS

SEE PICTURES OF INSECTS

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ON THE COVER.—(top) June beetle or adult white grub, differential grasshopper, (bottom) English grain aphid, armyworm on wheat head.
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Insects and Mites That Attack Wheat in Kansas

by
Reginald H. Painter, Harry R. Bryson, and Donald A. Wilbur

INTRODUCTION

Kansas produces more wheat than all the states that surround it combined. It is not surprising that insects cause extensive losses to wheat grown in the state. Some, like false wireworms, are pests only in western Kansas. Others, such as chinchbugs, damage wheat only in the eastern half. Still others, like grasshoppers and greenbugs, may occur in injurious numbers anywhere in the state.

At times outbreaks have been in a number of counties, at other times only on a few individual farms. Often it is necessary to be able to recognize the species of insects causing the damage, as control measures that work with one species may not work with closely related species.

Since before 1874, when...
Kansas was devastated by the Rocky Mountain grasshopper, hoppers have damaged wheat more or less each year (Fig. 1).

The hessian fly has caused heavy losses in central and eastern Kansas at intervals since 1885. In 1943 the loss was estimated at 25 million bushels. Harvey, McPherson, Reno, and Sedgwick county agents estimated losses of 50 percent of the crop in each of these counties, a total of 7 million bushels (Fig. 2).

Yield from 75 Temmerian Wheat Culms

| Uninfested by Hessian Fly | Standing and Infested by one Hessian Fly Flaxseed | Lodged and Infested by Fly |

Fig. 2.—A demonstration of the amount wheat yield was reduced by feeding of a single hessian fly larva.

Most of the insect pests of wheat can be controlled. Since 1913, when bran mash poisoned with arsenic was demonstrated in Kansas on a large scale, it has protected thousands of acres of crop land from grasshoppers, armyworms, and cutworms. The newer insecticides, toxaphene, chlordane, aldrin, and others, have given cheaper and more effective control under some conditions. Airplanes in spraying have made swifter coverage of large acreages possible.

Since about 1946 the Pawnee wheat, originated by the Kansas and Nebraska Agricultural Experiment stations, and Ponca wheat, bred at the Kansas Station, have greatly reduced damage by hessian fly (Fig. 3). These varieties have not only controlled the fly at no extra cost but have yielded better.

GENERAL METHODS OF CONTROL AND PREVENTION

Much loss from insects can be prevented by proper farm practices. Some of these practices have been recommended for agronomic reasons as well as for insect control. They can be used at little or no extra cost.

Destruction of volunteer wheat. Insects and mites that damage wheat maintain themselves chiefly on volunteer wheat and stubble from harvest until the fall crop is planted. Destroying volunteer, when that will not cause the soil to erode, is therefore strongly recommended. It is a pest control measure and a way to conserve moisture and soil fertility.

Hessian flies may increase in numbers in volunteer wheat, if the summer is cool and moist, and emerge in

3. Referred to hereafter as "Volunteer," the colloquial term.
greater numbers to infest the fall sown crop. Volunteer furnishes food for the occasional greenbug that passes some of the summers in Kansas. Volunteer provides pasture for aphids that migrate in during early fall before the regular crop is seeded. During the summer, volunteer furnishes food for grasshoppers. The hoppers then lay more eggs around the field borders where they may destroy newly planted wheat that fall or the following spring.

Volunteer wheat and associated weed grasses also are dangerous because they harbor wheat curl mites and wheat streak mosaic, which the mites carry. Destroying volunteer and annual weed grasses helps break up the life cycle of both the mite and the disease. Many wheat pests remain over periods unfavorable to them on volunteer. So the hazard to nearby seeded wheat when volunteer is left for pasture or other use should be weighed carefully with possible advantages before volunteer is left. Unless the possible advantage is great, volunteer should be destroyed as early as possible.

Fig. 3.—Comparison of infestation and injury to wheat varieties by hessian fly, Manhattan, Kan., November 1946. Each small stake is by an infested plant. Row 553, Ponca, 11% of the plants infested; Row 552, Tenmarq, 95% of the plants infested; Row 551, Pawnee, 65% of the plants infested.
Crop rotation, summer fallow, cultivation, etc. Some of the insects feeding on wheat do not attack many other plants. Hence in eastern Kansas, where it can be practiced, crop rotation reduces the hessian fly, wheat strawworm, wheat white grub, and other insects. Alternating cropping and summer fallow in western Kansas often serve the same purpose, tending to starve some of the mites, thrips, and other pests. This is particularly true when weeds are kept down. Russian thistle, for instance, serves as food and a place for Say's stinkbug, the thistle grasshopper, and other insects to lay eggs. Soil cultivation destroys insects or exposes them to birds and other enemies.

Time of planting. Seeding wheat when experiments have shown the maximum yield will result often in a good insect control practice. In eastern Kansas the time to seed wheat to escape hessian fly coincides rather closely with the date to seed wheat for greatest yields. This is less true in central Kansas. In central and western Kansas early planted wheat may be a source of infestation for surrounding fields by wheat curl mites that transmit wheat streak mosaic. Early planting should be particularly avoided if the disease or mite was prevalent the preceding year. Early planted wheat also helps greenbugs get established.

Timeliness in chemical control measures. When chemicals are used against insects, directions given should be followed exactly. Generally young insects are more easily killed than full grown ones. Full grown cutworms and grasshoppers eat far more in the last week of their growth than during all their preceding life. It is important, therefore, to locate infestations of them early, and where necessary, make treatments promptly and rapidly. For more extensive control operations airplanes and experienced commercial pest control operators are recommended. Many problems concerning sprayers and spraying are discussed in "Spraying Equipment for Weed Control," Bul. 66, Kansas State College Engineering Experiment Station. Detailed recommendations on insecticides often are omitted here because newer and better ones become available rapidly. The most recent information on insecticidal control can be obtained from the Department of Entomology or extension entomologist, Kansas State College, or the local county agent.

SOIL INSECTS THAT ATTACK WHEAT

Several species of subterranean insects attack planted seed and underground portions of wheat plants. The majority of them, which originally fed upon seeds, roots, underground stems of native prairie grasses and other plants, have survived cultivation, and find wheat suitable for survival and reproduction. When grow-
ing wheat is not available, they find food along fence rows in ravines, pastures, roadsides, and waste areas. Species that formerly lived on native plants often concentrate upon the wheat and cause considerable loss.

The most destructive soil insect pests are false wireworms, white grubs, true wireworms, and cutworms. Occasionally larvae of spotted cucumber beetles attack young wheat plants. Armyworms do most of their feeding above ground but undergo the pupal stage in the soil. While they also migrate to new feeding areas on the ground surface, they spend most of their time underground and therefore often are included in the soil insect group.

**False Wireworms.**

Three of about 11 species of false wireworms in Kansas (Fig. 4) have done the most damage to wheat. They are native prairie insects that originally fed on roots and ungerminated seeds of wild prairie plants, chiefly grasses. As the grassland was converted into wheat fields, the false wireworms were forced to feed on seed wheat and roots of the growing wheat.

**Description of the Stages.**

False wireworms have four stages: egg, larva, pupa, and adult.

The adults are black, grayish black, angular, awkward, robust beetles that often perform acrobatic turns, stand on their heads, or run quickly when disturbed. Their wing covers are marked with longitudinal ridges and are fused together, making the wings useless, so they crawl when they migrate. They vary in

---

**Fig. 4.—Comparative size and shape of the three common species of false wireworm beetles. Left, Eleodes opaca; center, Eleodes tricostata; right, Eleodes suturalis. Magnified 1½X.**
size from \( \frac{3}{8} \) inch to more than 1 inch in length and from \( \frac{1}{4} \) to \( \frac{3}{8} \) inch in width. Some species have a reddish brown longitudinal stripe on the line where the wing covers are fused.

The beetles often congregate under Russian thistles, or other weeds, and may be seen migrating in large numbers along roadsides. They sometimes take seeds away from mound-building prairie ants. They feed on seed wheat left in the field by combines, around stacks, on wild lettuce seeds, or on seeds of prairie grasses.

**Egg.** The eggs are white and oblong without characteristic markings. They are covered with a sticky substance that dry soil adheres to. As a result they are not readily observed in soil.

The female digs a small cavity \( \frac{1}{2} \) to 3 inches deep in dry soil where she deposits eggs singly. Several eggs may be placed in one cavity, which the female fills with soil after laying the eggs. A female may deposit 175 to 250 eggs during the egg laying period, which may extend from July 15 to late November. The long egg laying period accounts for great variation in sizes of larvae found during fall.

The adults prefer dry soil to lay eggs in and larval survival is highest in dry soil.

**Larva.** The white, oval eggs in 10 to 14 days hatch into yellow, glistening active cylindrical worms that turn dark as they become older (Fig. 5). They resemble mealworms, which commonly infest moldy stored grains, meal, and ground feeds. The larvae feed 1 to 6 inches down in the soil and come to the surface only when the soil is saturated with water. They have been seen crawling on the surface on such occasions.

![Fig. 5.](image-url)

**Fig. 5.** (Top) False wireworm. About natural size. (Bottom) Wheat kernels destroyed by false wireworms. Magnified 3X.

The larvae are approximately two-thirds grown when the soil becomes cold in November. They burrow below the frost line and remain inactive until spring. When the soil temperature rises, the larvae return to the surface and re-
sume feeding on weed seeds, roots, and wheat that did not germinate. Little injury is evident in the spring. An inactive state is then passed by the larvae before they transform to the pupal stage. The larval stage requires about 275 days, depending upon the species and the condition they develop under. Occasionally, a few larvae may change to pupae in the fall. Then adults appear early the next spring.

**Pupa.** This is an inactive stage in which the larvae transform to adults. Pupae are white at first, changing to a creamy color as they develop. The mandibles (jaws) and tarsi (feet) change to reddish-brown or black.

Pupation begins during the last week in May and continues through June. This long period of pupation corresponds to the long period eggs are deposited in the fall. The pupal stage requires about 20 days. The greatest number of beetles emerges from June 24 to July 1.

The newly emerged adults mate and begin laying eggs around July 10 and deposit most of the eggs by August 31. An individual pupal stage requires about 17–20 days. Thus, the life cycle of most species is only one year.

**Description of Injury.**

Although the adults feed on seeds scattered on the soil, the greatest injury caused by these larvae is during dry fall seasons following dry summers. They usually increase rapidly in a series of dry years. Wet years have the opposite effect on them.

Often seed wheat is planted early in the fall in soil too dry to germinate the seed rapidly. Considerable damage by the larvae often results when seed is “dusted in” and lies several weeks before rainfall starts germination.

Larvae follow the drill rows and eat the germ of the kernels (Fig. 5). A single larva is capable of destroying a large number of kernels. Since the moisture content of the soil often varies within a given field, and the number of larvae in one spot may differ from that of another area, an irregular stand may occur. Drought often is blamed.

Numerous larvae often seriously injure young seedlings by cutting them off below the surface of the soil immediately above the node where the permanent roots arise. But seedling injury is not so common as damage from larvae feeding on the seed.

**Control.**

Considerable injury to fall-sown wheat may be avoided by sowing seed only when there is enough moisture to stimulate rapid germination. Wheat should not be planted too early or “dusted in” because the longer the seed lies in the soil without germinating, the greater the opportunity for injury.

Clean culture and accumulated soil moisture associated with summer fallowing tend to reduce the amount of in-
jewelry. Destroying weeds eliminates shade and hiding places for beetles to congregate, escape the heat, and deposit eggs.

Since the wingless beetles are forced to crawl where they go, a cropping system of wheat following wheat favors them. This continuous cycle may be broken by planting sorghums, legumes, crops other than wheat, or by fallowing. Such areas are less attractive to egg laying females and may starve the larvae.

Chemical control may be possible since the introduction of new insecticides but is not practical.

**Seed treatment.** Applying chemicals to seed promises to be effective and a more economical control measure than treating the soil. Aldrin or heptachlor applied at the rate of 2 or 3 oz. actual toxicant to 100 lbs. of seed appears to be effective and does not retard germination or injure the seed.

Seed that is treated should have high germination because weak, inferior seed sometimes is injured by the chemicals. The chemicals may be used alone or in combination with fungicides recommended to control seed-borne diseases of wheat.

Preliminary studies indicate that holding the seed in storage following treatment and prior to planting does not increase the toxicity of the chemical. Several seed treating chemicals are sold under various trade names, usually in the form of wettable powders. They will not injure the seed if applied at rates recommended. Overdoses of chemicals may injure seed.

Chemical control should not be necessary if certain planting procedures and cropping practices are followed year after year. The amounts and kinds of insecticides to be recommended change frequently as new and better methods are discovered through research. For latest recommendations consult the Department of Entomology or the extension entomologist, both at Kansas State College, Manhattan, or your county agent.

**White Grubs.**

There are three general groups of white grubs (Fig. 6) that injure growing wheat plants. The 1-year-cycle grub

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5. *Cyclecephala immaculata* Olliv.
is responsible for the greatest injury to wheat in the western one-half of the state. A 2-year-cycle grub, known as the wheat white grub does the most damage in south-central Kansas and several three-year cycle species are worst in the eastern half. There are four stages in the life cycle (Fig. 6) of all.

No definite lines separate the areas. All three groups are present in all parts of the state. Often more than one species may cause injury within a given area.

**Description of Stages.**

**Adults.** The adults (Fig. 6) of the one-year cycle grubs are small, yellowish brown beetles about \( \frac{1}{2} \) inch long and \( \frac{3}{8} \) inch wide. They fly to lights in large numbers from about June 15 to August 1. These beetles are active at night and remain in the soil during the day. They eat little, if any, so cause no injury. Observations indicate that they deposit eggs in moist soils rich in organic matter or decaying straw.

The wheat white grub requires two years to complete its life cycle, beetles being most numerous during even-numbered years (1956, 1958, etc.). The females of this species are tannish, round, almost globular in outline, wingless and have comparatively long legs. The males are smaller, grayish, with wing covers not fused, more elongate, and with straighter sides. There is evidence of faint dark longitudinal stripes on the wing covers of both sexes, more pronounced on males than females.

Both sexes are active in early daylight hours. They feed on leaves of many plants such as dandelions, pig weed, wild alfalfa or “tumble weeds,” etc. During the heat of the day, they burrow into the soil for protection and to deposit eggs. The males fly but the wingless females crawl from plant to plant.

In the northern part of the state, the species is more commonly found on uplands; in the southern part, it is confined to lowlands.

There are several species of three year cycle grubs that feed on roots of farm crops but only four or five are injurious. The beetles of this group vary from \( \frac{1}{2} \) inch to almost \( \frac{3}{4} \) inch long and vary from light brown to reddish brown. Some are covered with grayish to yellowish hairs. Others are shiny and almost hairless.

Both sexes are active, dusk or evening fliers. They feed at night on leaves of trees, shrubs, weeds, vines, and low growing vegetation. They do not feed upon the leaves of wheat and prairie grasses. At dawn they fly to fields where they burrow into the soil. The beetles also are attracted to bright lights.

**Egg.** The females deposit eggs singly in cavities in soil.

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Fig. 7.—Egg of wheat white grub in pellet of soil. The cavity about the egg was formed by the female beetle when the egg was laid. Magnified 5X.

2 to 8 inches deep (Fig. 7). Four to six eggs may be deposited within a few inches of each other. This accounts for the spotted grub infestation. Often eggs are deposited around the roots of plants such as sunflowers or iron weeds or in loose soil rich in organic matter.

The eggs are oval, pearly white and about 1/16 inch long when first laid, but become yellow and darker just before hatching. The eggs vary in size, depending upon the species, but all require about 15 days to hatch.

**Larva.** The larva are known as white grubs (Figs. 6, 8). Grubs of all species are fleshy, curved larvae with brown heads, strong chewing mouth parts, and six rather short legs with a dark accumulation of material in posterior parts of the abdomen. Some species are sparsely covered with short hairs. Larvae of the one year cycle species are bluish in color.

The grubs vary in size when mature but have a similar external appearance. Larvae of the one-year cycle feed from August until the soil becomes cool in November when they burrow below the frost line to hibernate and return to the surface the following April or May to feed for a short time. Then they burrow down and change to a pupa.

The larvae of the wheat white grub spend two winters in the soil and pupate in the second spring of their life cycle. Their greatest feeding period is the second summer and fall of their life cycle.

Grubs of the three year cycle species feed three summers and spend two winters as larvae, while the last winter is spent as an adult in the pupal cell well below the frost line. The larvae pupate in late summer of the third season.

**Pupa.** The pupal stage is spent in the soil and usually requires about 15 days to transform to adult.

**Grub Injury to Wheat.**

White grub injury to wheat plants may occur in the fall or spring and may be recognized by wilted, dying, or dead plants. Damage to young wheat plants may be expected when an infestation numbers four or five grubs to 1 square foot. Growers may see large numbers of white grubs brought to the surface when preparing the land for wheat.

Usually white grub infestations occur in irregular spots
INSECTS THAT ATTACK WHEAT

in the fields. These spots gradually widen in diameter as the feeding period continues. Grubs do not migrate horizontally in the soil any farther than necessary to obtain food. Usually this spotted condition may be attributed to such conditions as abundance of organic matter, moisture, or grassy cover which attracted the females to the area to deposit eggs.

In the fall, the grubs follow drill rows cutting off young wheat seedlings just below the surface. One grub may follow a drill row and destroy a large number of seedlings. The grubs continue feeding in late summer and fall until the soil becomes cold in November.

Grubs may injure wheat plants in the spring during the heading period. The roots may be severed, holes eaten into the crown, and the plant killed (Fig. 8).

A reported 337,000 acres of Kansas wheat had to be plowed the fall of 1937 and planted to a spring crop in 1938 because of the wheat white grub. Except in certain years when grub infestations are heavy, wheat plants grow rapidly in the spring, before grubs return to the surface, so little injury from them is evident in the spring.

**Control.**

1. Practice clean culture, including destruction of weeds in and along borders of the field to remove food plants adults of the wheat white grubs feed on. Clean culture of rowed crops, especially sorghums, also aids.

2. Use a crop rotation system including legumes such as alfalfa, sweet clover, or soy beans. Wheat should not follow wheat year after year.

3. Do not sow wheat too early. That exposes young seedlings to the feeding activities of grubs longer before cold weather forces them to hibernate.

4. DDT, aldrin, chlordane, heptachlor at rates recommended for lawns will control white grubs in wheat, but ordinarily will be too expensive at present. Any of these chemicals should control the larvae

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Fig. 8.—Injury to crown and roots of maturing wheat plant by three-year-cycle grubs. About natural size.
for about three years when applied to the surface and worked into the soil 3 to 6 inches deep. Heptachlor at 2 lbs. has proved effective for one-year-cycle grubs.

The amounts and kinds of insecticides to be recommended change frequently as new and better methods are discovered through research. For latest recommendations consult the Department of Entomology, Kansas State College or the extension entomologist, both at Manhattan, or your local county agent.

**True Wireworms.**

Several species of true wireworms may be found around roots of growing wheat plants. Some have a three-year life cycle, but the most common species require only one year from egg to adult. Their life cycles, stages, and habits are similar to those of white grubs, requiring the same number of years to complete the life cycle.

True wireworms are the larvae of brownish to black, slender, active beetles that have a loose, flexible connection between the prothorax and middle part of the thorax. This loose joint contains a structure that enables the beetle to make a clicking sound and to "jump" or throw itself some distance when it is disturbed or placed on its back.

The beetles work at night, feeding on pollen, honeydew, or other sweet substances, but cause no injury to crops. The females lay eggs in moist soil slightly below the surface near the roots of grassy plants. Heavy infestations of wireworms are nearly always associated with sod or grassy fields. The eggs hatch in about 10 days into small, wiry, elongate larvae.

![Fig. 9.—True wireworm. Magnified about 1½X.](image)

The larvae (Fig. 9) feed on small roots, organisms in the soil, or germinating seeds, but cause no damage in the first year of their three-year cycle. The second year of their cycle usually is the one when they cause the most injury. Wireworm larvae are light tan to brown or reddish-brown, ordinarily cylindrical, but some species are flat with flattened heads that point forward.

**Types of Injury.**

Wireworms may attack the germinating seed, but rarely cause damage. Their greatest injury to wheat plants is their feeding on the roots when the plants are small, boring into the underground portion of the stem, or boring into the node from which the permanent roots arise. Since wireworms are not especially active in the fall, they cause little injury to the young wheat plants. In the spring, the wheat plants are so large and are developing so rapidly they are not easily destroyed by wireworms.
Control.
Where control measures are necessary, those effective against white grubs will control wireworms.

BIOLOGY, DAMAGE, AND CONTROL OF INSECTS THAT ATTACK WHEAT ABOVE GROUND

GRASSHOPPERS

There are more than 130 species of grasshoppers in Kansas. However, a single species, the lesser migratory grasshopper, does an estimated 90 percent of the hopper damage to wheat in normal years. In years of grasshopper outbreaks, several additional species attack wheat. Most grasshoppers have feeding habits restricted to a few native plants. Some species feed only on a single kind of plant and would starve in a wheat field or alfalfa field. Those that damage crops feed on an appreciably wider range of food plants.

The more important crop damaging grasshoppers.

Lesser migratory grasshopper.\(^8\) This species prefers light, well-drained soils and sparse vegetation. Fields of wheat stubble provide favorite sites for egg deposition. Unlike other grasshoppers, this species may develop two generations a year. When this occurs the second generation hatches as the fall-sown wheat is germinating and may cause extensive damage (Fig. 1).

Differential,\(^9\) two-striped,\(^10\) and red-legged grasshoppers.\(^11\) These species prefer moist conditions with heavy soil. They are at home in rank vegetation along streams and in low spots. Primarily, these grasshoppers are pests of corn, alfalfa, and crops other than wheat but they also will damage wheat, particularly under outbreak conditions. The differential and two-striped grasshoppers prefer fence rows, roadsides, and sod lands bordering cultivated fields for egg deposition sites.

Packard’s grasshopper.\(^12\) This grasshopper normally lives in the grasslands but may move into wheat and other crops during part of the summer. There are several other grasshopper species that prefer grasslands but occasionally damage wheat.

Thistle grasshopper.\(^13\) Before wheat harvest large numbers of thistle grasshoppers may be found in wheat fields weedy with Russian thistles. Normally they do not damage wheat.

Life history and habits.

Grasshoppers lay eggs in packets or egg pods, each containing from 15 to 125 eggs. Under favorable conditions a single female may produce several egg pods. Egg pods are deposited in the soil, on the surface of the soil, or at the base of bunch forming

\(^8\) Melanoplus mexicanus (Sauss).
\(^9\) Melanoplus differentialis (Thos.).
\(^10\) Melanoplus bivittatus (Say).
\(^11\) Melanoplus femur-rubrum (Deg.).
\(^12\) Melanoplus packardii (Scudder).
\(^13\) Aeoloplns turnbulli (Thomas).
grasses. Egg laying may begin in early summer and extend into the fall.

Eggs of most crop damaging grasshoppers do not hatch until between early April and mid-June of the following spring. An important exception is the lesser migratory grasshopper. During some seasons many eggs of this species hatch during August and September. The nymphs immediately attack fields of fall sown wheat (Fig. 1). If favorable conditions persist into the fall, the second generation nymphs mature and deposit eggs. However, an early winter may destroy the grasshoppers before they lay eggs. This diminishes their numbers for the following year.

Hatching time, as with most grasshopper activities, depends on species, temperature,

Table 1.—Identification by color pattern of older nymphs of the four common injurious grasshoppers.*

<table>
<thead>
<tr>
<th>Species</th>
<th>femoral stripe</th>
<th>compound eye</th>
<th>pronotal crescent</th>
</tr>
</thead>
<tbody>
<tr>
<td>M. meridionalis</td>
<td>broken by a light transverse band,</td>
<td>weakly barred with little difference in degree of</td>
<td>reduced to a mere spot in dark individuals and a white crescent continuing part way across the gena</td>
</tr>
<tr>
<td></td>
<td>or, in darker individuals, by a pale spot</td>
<td>pigment above and below the bar</td>
<td></td>
</tr>
<tr>
<td>M. femurrubrum</td>
<td>covers upper chevrons and upper third of</td>
<td>light spots occupy as much area as dark pigments.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>lower chevrons and has an even ventral margin</td>
<td>Strong tendency to banding, lower half being noticeably darker</td>
<td></td>
</tr>
<tr>
<td>M. differentialis</td>
<td>covers at least one-third lower row of chevrons. Two dark marks on upper flange of femur extend across the femur on the inside, forming two dark bars</td>
<td>eye spots not uniformly distributed</td>
<td>either absent or obscure</td>
</tr>
<tr>
<td>M. bivittatus</td>
<td>barely touches the lower row of chevrons and irregular along lower margin</td>
<td>uniform distribution of small rounded light spots on a brown basal color of eye. Spots may be distinctly separated or may join but are always uniformly distributed</td>
<td>inconspicuous, does not reach head</td>
</tr>
</tbody>
</table>

and moisture. When the spring is warm and dry, eggs hatch earlier and nymphs develop rapidly with a low death rate. But when the weather is cold and damp during hatching, mortality of nymphs may be high and threatening outbreaks curtailed.

Nymphs resemble their parents except in size and lack of functional wings. From 5 to 9 weeks are required for nymphs to mature. Identification of older nymphs of the four common injurious grasshoppers can be accomplished through difference in color pattern (Table 1).

Damage to Wheat.

Grasshoppers damage wheat chiefly by eating the leaves and stems. Lesser migratory grasshoppers feed on leaves of the wheat plants until harvest. The nymphs or adults remain in the stubble eating various weeds until volunteer wheat plants develop. First generation adults and second generation nymphs move from stubble fields into edges of wheat fields in the fall and consume the young plants. Frequently this necessitates replanting field margins. In areas where strip cropping is practiced, the long narrow strips of wheat bordered on either side by stubble strips are especially vulnerable to hopper damage (Fig. 1).

In the spring as the head stalks emerge, grasshoppers tend to climb the stalks, gnaw on the ripening kernels, and roost on the head. This results in extensive shattering of grains. The gnawing is erroneously mistaken for weevil damage by many persons. Nearly every year in some part of the state hoppers climb up stalks and chew into and sever the stalks under the wheat heads. The severed heads fall to the ground and cannot be recovered. Occasionally this type of damage is widespread with considerable losses.

Grasshopper Control

Effective grasshopper control results from a combination of proper management, tillage methods, and insecticidal treatments. Cooperative action in a community is essential when outbreaks are widespread. Kansas wheat growers have pioneered outstandingly successful cooperative bait spreading programs.

Management Practices.

Proper management helps prevent grasshopper outbreaks in regions where the hoppers do not migrate. Such practices include:

1. Eliminating unnecessary fence rows and weedy roadside strips that provide shelter and egg-laying sites for grasshoppers.
2. Substituting sorghums that resist grasshoppers when outbreaks are impending.
3. Applying insecticides before seeding wheat when stubble fields and roadsides have many hoppers.
4. Adjusting the size and shape of the fields to leave a minimum of field margin adjoining stubble fields in areas
where grasshoppers are an annual problem.

5. Other management practices sometimes used include: Pasturing with turkeys, use of hopper catchers or hopper dozers, and establishing barrier strips or trap strips where the hoppers gather and can be poisoned.

**Tillage Methods.**

Tillage may destroy grasshopper eggs by burying or crushing them, or by lifting them to the surface where they may dry out or be eaten by rodents, birds, or other predators. Tillage loosens the surface of the soil so it is unsatisfactory for hoppers to lay eggs. They prefer firm undisturbed soil for this purpose. Tillage also destroys weeds which provide food and shelter for the hoppers.

1. Plowing grasshopper eggs under 5 or 6 inches in stubble fields will prevent most of the nymphs from escaping from the soil. Moldboard plows are outstandingly effective. Disk plows with attachments to turn the furrow slice also are effective. Disk plows, one-ways, or other tillage implements which fail to bury eggs under 5 inches of soil are appreciably less effective. In Kansas plowing for grasshopper control should be done in the spring after danger from blowing has subsided.

2. If grasshopper-infested stubble land cannot be summer fallowed before the eggs have hatched, a barrier strip at least 4 rods wide should be plowed around the entire field to retain the grasshopper nymphs in the field. As summer fallowing proceeds, the nymphs will move towards the center of the field. Here, they should be baited or sprayed before they develop wings and fly to nearby crops.

3. Summer fallowed land, to be seeded to wheat in the fall, should be maintained free of volunteer wheat or other weeds during summer and early fall. The tillage required for this keeps the seedbed free of grasshopper eggs.

4. When wheat areas are near alfalfa fields where hop per oviposition has been heavy, cultivate the alfalfa fields during late fall or early spring with a spring-tooth harrow.

**When To Apply Insecticides.**

It is important that insecticides be applied in the spring while the hoppers are young, before they leave fence rows, stubble fields, idle lands, or the fields themselves. When hoppers are destroyed before egg laying begins, control for several years often can be secured for the price of one thorough application. Insecticides can be applied to alfalfa fields immediately after the first cutting without danger of the residual spray poisoning the forage for livestock. If damage to margins of newly sprouted wheat fields is to be avoided in the fall, insecticides should be applied to margins of the bordering areas before the new wheat is up. Light
INSECTS THAT ATTACK WHEAT

populations in stubble fields become heavy populations in wheat field margins.

Insecticidal Treatment.

There are three methods of applying insecticides to control grasshoppers: spraying, dusting, and spreading poisoned bait. They may be applied with either ground equipment or airplane. Since 1946 the new toxicants aldrin, chlordane, heptachlor, and toxaphene have been developed. They kill faster and last longer than the arsenicals or fluosilicates formerly used. They may be purchased as emulsifiable concentrates, oil solutions, or wettable powders and are suitable for any of the three methods of application. Which to use—spray, dust, bait.

Phenomenal kills of grasshoppers have been secured from spray applications of the new toxicants. In general, sprays are preferable to baits because they are more effective under most conditions and because they are cheaper to use. Bait materials are difficult to obtain in quantities for large scale control programs. Baits may be more effective in preventing damage to margins of newly sprouted, fall sown, wheat fields where the plants have not yet developed enough leaf surface to hold killing concentrations of sprayed insecticides. However, since only a small part of an infestation is reached by marginal baiting, the general infestation is not reduced appreciably. Since baits are stomach poisons, they must be applied just before or during the short period of the day when grasshoppers are actively feeding. They become less attractive to hoppers within a few hours after application. Sprays containing the new toxicants are both stomach poisons and contact poisons. Hoppers touched by droplets of spray are killed as well as those that eat the sprayed foliage.

Sprays have been more successful than dusts because sprays have greater killing action at lower dosages, they last longer, they adhere to foliage better, and they are less harmful to bees.

Sprays.

The amount of actual toxicant to be applied per acre should be any one of the following:

<table>
<thead>
<tr>
<th>Toxin</th>
<th>Quantity</th>
<th>Days between application and use by animals</th>
</tr>
</thead>
<tbody>
<tr>
<td>aldrin</td>
<td>1 1/2 to 2 ozs.</td>
<td>15</td>
</tr>
<tr>
<td>chlordane</td>
<td>1/2 to 1 lb.</td>
<td>30</td>
</tr>
<tr>
<td>dieldrin</td>
<td>1/8 to 1 oz.</td>
<td>30</td>
</tr>
<tr>
<td>heptachlor</td>
<td>3 to 4 ozs.</td>
<td>10 to 15*</td>
</tr>
<tr>
<td>toxaphene</td>
<td>1 to 1 1/2 lbs.</td>
<td>40</td>
</tr>
</tbody>
</table>

*Between application and cutting or pasturing alfalfa or clover, 10 days; pasturing range grass, roadsides, field margins, etc., 15 days. The higher amounts of toxicants (poisons) recommended in the preceding table should be used under the following circumstances: older grasshoppers, taller dense vegetation, dryer vegetation, when longer residual action is needed, and when higher temperatures prevail.

The type of insecticide depends on the type of spraying equipment. For airplane application, oil solutions at 1 gallon
per acre are recommended. For ground application dilutions of 15 to 50 gallons of water per acre may be necessary. Wettable powders tend to clog the nozzles at lower dilutions.

**Dusts.**

When dusts are used, the dosages of actual toxicants per acre in the preceding table should be increased 50 percent.

**Baits.**

The amount of actual toxicant to be applied per acre in baits regardless of the type of formulation is as follows:

- Aldrin ............... 2 ounces, or
- Chlordane ............ ½ pound, or
- Heptachlor ............ 4 ounces, or
- toxaphene ............. 1 pound

In preparing wet baits the correct quantity of one of the above toxicants is added to 100 pounds of bran or to 25 pounds of bran and 3½ bushels of sawdust. Water, between 10 and 12 gallons, is added to the above mixture to make a wet, crumbly mash. This is spread 20 pounds per acre.

Dry baits for airplane application may be prepared as follows: mix one of the above poisons with ½ gallon of fuel oil or kerosene; atomize the oil solution uniformly over 100 pounds of coarse, dry bran; apply at the rate of 5 to 10 pounds per acre.

**Precautions.** As recommended by the Department of Agriculture:

All the poisons recommended for grasshopper control are poisonous to man and animals, but the diluted sprays are not dangerous to handle if ordinary precautions are followed. After spraying or dusting, bathe thoroughly and change to clean clothing. If you spill any spray material on the skin, bathe immediately.

If the insecticide is accidentally swallowed, induce vomiting by taking 1 tablespoonful of salt in a glass of warm water. Repeat if necessary. Call a doctor.

Do not feed forage or chaff contaminated with these insecticides to poultry or dairy animals, or to meat animals during the last two months before slaughter.

**THE HESSIAN FLY**

The hessian fly was first reported in a few eastern counties of Kansas in 1871, a little less than 100 years after it had been brought to this country by Hessian soldiers during the Revolutionary War. It has spread westward in recurring outbreaks at intervals of 5 to 10 years until it now has been reported from all Kansas counties except a few in the extreme southwest. Each outbreak of hessian fly often has cost the state $50,000,000 or more. The last severe outbreak occurred from 1942 to 1945.

**Damage.**

The best-known damage done by the hessian fly is the breaking over of culms somewhat before harvest time (Fig. 10). Their flaxseed is to be found where the break occurs. Many culms infested by flaxseed do not break over. Heads

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carried on these culms yield 25 to 30 percent less than heads on uninfested culms (Fig. 2). In the fall the hessian fly kills tillers and young plants (Fig. 11). This damage may be identified by finding the flaxseed or larvae at the base of dead plants or tillers. Fall damage results in a thinner stand that may be mistaken for winter injury. The white larvae and the brown flaxseed are the stages most frequently found. The adult hessian fly lives for such a short time that it is seen rarely.

Life History.

Eggs of the hessian fly are laid on the upper surface of young leaves of wheat. Each female lays 100 or more eggs (Fig. 12) during the few hours she lives. Larvae hatch from eggs in a few days and make their way to where the leaf joins the stem. There the larvae (Fig. 13) remain feeding on plant juices and growing for nine or more days. When the larvae are fully fed the last larval skin hardens and turns brown to form the well-known "flaxseed" stage.

Fig. 10.—Type of lodging caused to wheat by spring generation of hessian fly.
Fig. 11.—Left, a normal wheat seedling. Right, a wheat seedling infested with hessian fly. Note the broad flat central leaf compared with the narrow round central leaf of the normal wheat plant. Infested plants frequently die in the fall.

(Fig. 13). If conditions are favorable, the adult fly (Fig. 14), appearing like a small black mosquito, emerges in a week or two. This insect ordinarily passes the summer (Fig. 15) and winter (Fig. 13) in the flaxseed or resting stage. In this stage the fly resists unfavorable weather and may remain alive for as long as four years. Ordinarily there are only two or three broods a year, but in Kansas as many as five broods have been recorded in a 12-month period. The life from egg to adult requires at least 20 days, more often about a month.

While susceptible varieties of wheat are its principal host plants, the hessian fly can mature on most varieties of
Fig. 13.—(Top) Hessian fly larvae (white just above roots) on young wheat. Note broadening of leaf on tiller attacked by fly. Magnified approximately 11/2X. (Bottom) Hessian fly flaxseed on tillers of seedling wheat, dark and oblong just above roots. Magnified approximately 11/2X.

Fig. 14.—(Top) Hessian fly adult, male. Magnified approximately 8X. (Bottom) Hessian fly adult female. Magnified approximately 8X.

Fig. 15.—Flaxseed of hessian fly on wheat culms showing variation in the amount of stunting of culms and internodes caused by feeding of this insect.
barley, rye, and a few wild grasses as western wheatgrass, wild rye, and little barley. It has never been reared on oats.

Weather conditions that favor wheat also favor hessian fly. This insect requires fairly moist, mild conditions. Abundant volunteer also favors the increase of this insect. Hot, dry weather lengthens the life cycle of the hessian fly and often reduces infestations.

**Control.**

Control of hessian flies is prevention. Once flies infest a crop, they cannot be destroyed by any known way until after harvest.

**Early plowing of wheat stubble** is the first step to prevent infestation of the new crop. This step in control is especially practical in eastern and central Kansas.

The destruction of all volunteer wheat as soon as it sprouts prevents infestation of the volunteer and increase of flies during summer. The destruction of volunteer also saves moisture and soil fertility. If fall pasture is seeded, Balbo rye may be planted, since it is immune to fly.

**Planting wheat at the time recommended by the state agricultural experiment station or the county agricultural agent for each locality** (Fig. 16) aids in avoiding infestations. Wheat should be seeded as soon as possible after this safe-seeding date. Resistant varieties may be planted somewhat earlier in years when flies are less abundant. If hessian fly susceptible varieties are planted, the safe-seeding date should be followed exactly.

Cooperation with all other farmers in the community in all hessian fly control practices is important in prevent-

Fig. 16.—Map of Kansas showing approximate safe dates for planting wheat to avoid hessian fly injury. Hessian flies occur in some of the southwestern counties, but present data are insufficient to determine correct dates.
ING outbreaks because the insects can fly at least 5 miles.

**Planting resistant, adapted varieties** is an important defense measure against hessian fly. Pawnee wheat carries considerable resistance to the fly in Kansas west of a line from Brown to Cowley counties (Fig. 17).

Ponca wheat is highly resistant to hessian fly and adapted to southeastern and southern central Kansas.

Some fly infestation may occur on both these varieties, especially Pawnee. Mixtures of these varieties with susceptible ones cannot be expected to give good fly control. New and improved fly-resistant wheat varieties should be used as they become available and recommended.

**GREENBUGS AND OTHER WHEAT APHIDS**

Among about a dozen different kinds of aphids known to attack wheat in Kansas, only the greenbug is highly destructive because of its feeding activities. Aphids may be distinguished from other insects on wheat by their small size and by the presence of a pair of slender tubes, the cornicles, that extend from near the tip of the abdomen (Fig. 18). Aphids form characteristic colonies consisting of a few larger, winged or wingless adults and many small nymphs.

On wheat plants most aphids consist predominantly of females which give birth to living young. These two facts explain their tremendous reproductive rate. In the accompanying table (Table 2) are shown the distinguishing characteristics of colonies of the common aphids found on wheat in Kansas. It is suitable for tentative identification. Careful microscopic examination of specimens often is needed to be certain which species is present. Green

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**Fig. 17.**—Map of Kansas showing approximate area where Pawnee wheat carries considerable resistance to hessian fly.
### Table 2.—Distinguishing characteristics of wheat-feeding aphids as seen in the field with a hand lens.

<table>
<thead>
<tr>
<th>Kind of Aphid</th>
<th>Common location of colony and time of occurrence</th>
<th>General color of wingless aphids</th>
<th>Appearance of winged aphids</th>
<th>Local injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenbug (^1) (Fig. 22)</td>
<td>Exposed on upper sides of leaves, or behind boot. September to June.</td>
<td>Bright green, except black tips of legs, cornicles, and all of antennae and eyes.</td>
<td>One forked vein in wing; body green and brown; legs as in wingless aphids.</td>
<td>Leaf turns yellow under the colony. Often red spots in center. Small plants killed quickly.</td>
</tr>
<tr>
<td>English grain aphid (^2) (Fig. 21)</td>
<td>Exposed on leaves and on heads. September to June.</td>
<td>Bright green. Legs, cornicle, and antennae black.</td>
<td>Two forks in wing vein. Body green and brown with black legs and cornicles.</td>
<td>No evident injury.</td>
</tr>
<tr>
<td>Apple grain aphid (^4)</td>
<td>Often on lower side of leaves or leaf sheaths and heads. September to November, April to June.</td>
<td>Larger ones dark green with reddish spot on center of abdomen.</td>
<td>Two forks in wing vein. Body black.</td>
<td>No evident injury.</td>
</tr>
<tr>
<td>Corn leaf aphid (^5)</td>
<td>Deep in whorl of middle leaf. Usually present only in fall of year.</td>
<td>Blue-green with black spot about base of each cornicle.</td>
<td>Two forks in wing vein. Body black.</td>
<td>No evident injury to wheat, but injures corn and sorghum during the summer.</td>
</tr>
</tbody>
</table>

1. *Toxoptera graminum* (Rond). Fig. 22.  
2. *Maconellicoccus hirsutus* (Kirby). Fig. 21.  
aphids found on alfalfa are pea aphids, sometimes mistaken for greenbugs. Although they look somewhat alike, greenbugs do not live long on alfalfa and pea aphids will not survive on wheat, barley, or oats.

Greenbugs are the only aphids on wheat that have required insecticidal control. In addition to sucking the sap, as all aphids do, greenbugs inject a salivary fluid that is highly injurious to the plant. This salivary fluid turns the green coloring matter of the plant yellow, causes breakdown of some plant cells, and interferes with some vital processes in the plant (Fig. 18).

The greenbug was described in Italy in 1852 and is known also from other European and Asiatic countries, Africa, and North, Central, and South America. It was first reported in the United States in 1882. There have been severe greenbug outbreaks in Kansas in 1907, 1916, 1934, 1939, and 1949 to 1950, and less damage in other years.

In several of these years the greenbug has appeared suddenly in the early spring, killing areas of wheat. In these typical "greenbug spots" the dead wheat in the center looks as if it had been scorched by fire. The "fire" spot is surrounded by a narrow circle of wheat plants covered by the active greenbugs (Fig. 19). Later the spots may spread until most or all of the field is destroyed; or winged aphids

Fig. 18.—(Top) The English grain aphid. Note the two cornicles (tubes projecting from hind end of body and characteristic of most aphids). The black legs and black cornicles distinguish this species from the green bug. Magnified approximately 10X. (Bottom) Colonies of green bugs on wheat leaf showing also the yellowing that follows their feeding. Magnified approximately 10X.
Fig. 19.—A small "green bug spot" in a wheat field near Manhattan in April. The wheat in the foreground was killed by green bugs that probably overwintered in the clumps of volunteer in the center of the spot.

may develop and insects scatter to many fields. Infestations that develop in this manner indicate that the insect overwintered in the locality. South-facing slopes, heavy volunteer patches, especially of barley, are favorable places for hibernation.

The greenbug is known to have passed some mild winters as far north as Manhattan. In some years it flies into the state from areas to the south where it more commonly overwinters. In these cases widespread infestations occur.

In May and June the greenbugs sometimes find their way behind the upper leaf sheath or "boot" about the developing head (Fig. 20). Here, protected from their insect enemies and, to a considerable extent, from insecticides, colonies develop rapidly. The wheat heads are stunted, spindle-shaped (Figs. 21, 22), with grains developing only in the central part of the head. Plants in fields of wheat injured this way appear ragged. The degree of injury appears to be influenced by the vigor of the plant concerned.

In the fall greenbug populations may fly in, or develop in Kansas from the few individuals that survived the summer. During the warmer fall weather, parasites and predato-
tors limit aphid populations. With the beginning of cooler weather greenbugs may increase faster than their enemies. In the late fall, greenbugs may kill some small wheat plants and stunt others, preventing normal tillering. This reduces possible yield by thinning the plants and limiting the number of heads produced the next summer. If moisture and other conditions favor a good crop, insecticidal treatment in the fall might be profitable when greenbugs are found in numbers. This is especially true of eastern Kansas.

Damage.

Four types of injury may be done by greenbugs in Kansas: (1) killing wheat plants in fields (greenbug spots, Fig. 19) in early spring, by greenbugs that overwintered there; (2) widespread infestations and injury of plants in many fields in the early spring by winged greenbugs that flew in from the south; (3) reducing

Fig. 21.—Heads of wheat stunted by the feeding of green bugs when heads were within the boot compared with a normal head on the left.
yields by stunting heads when greenbugs feed behind the upper leaf sheaths or boots (Figs. 21, 22) in May and June; and (4) thinning plants and preventing tillering by the late fall feeding.

The greenbug can live on many grasses but not on broad-leafed plants like alfalfa. In addition to wheat, favorite host plants include oats, little barley, barley (especially winter barley), and crabgrass.

Fig. 22.—Wheat plants stunted by late spring feeding of green bugs compared with normal plant from same field on the left.
Corn and sorghums are occasionally attacked, but rarely damaged in the field. Infestations in southern Kansas frequently develop on winter barley which, planted early and catching any aphids coming by, makes a good growth and provides excellent winter protection for the aphids.

Males and eggs are rarely seen in Kansas; most of the females begin reproduction 6 to 30 days after they are born as living young. They continue to give birth to two or three aphids per day for from 20 to 30 days. Many generations may be produced in a year under favorable conditions.

**Biological Control.**

Greenbugs are most likely to become abundant when a cool, moist summer is followed by a mild winter and a late cool spring. Normally the greenbug feeds on leaves exposed to rain, predators, and parasites. A heavy, dashing rain greatly reduces greenbug population. In cold, windy weather the insects crawl down to more protected places near the ground. A temperature of about 0°F., if it persists for long at the ground level where the insect is hiding, will kill most greenbugs. Greenbugs can live and reproduce slowly under the snow at temperatures when most insects, particularly the parasites and predators of the greenbug, are dormant. Under normal weather conditions the natural enemies of the greenbug, especially ladybird beetles (Fig. 23) and a small wasplike parasite, are able to reproduce as fast as the greenbug and thus prevent its destructiveness. The greenbug can bring forth its living young at about 40°F., while its parasites and predators do not lay eggs until the daily temperature reaches about 65°F.

Several different species of ladybird beetles feed on greenbugs. These beetles are small red or orange-yellow insects with black spots on their backs. Large numbers of greenbugs are eaten. The ladybird beetles lay their yellowish eggs near the aphid-covered wheat plants. The black and red alligator-shaped larvae (Fig. 23) of the ladybugs that hatch from these eggs are even more ravenous feeders than their parents. Many hundreds of greenbugs are eaten by the larvae before they climb up a blade of wheat, fasten themselves by their tails, and rest for a few days before emerging as adult beetles. The larvae and pupae are sometimes incorrectly thought by farmers to be the insects causing the damage to wheat.

One parasite in particular is effective in keeping the greenbug from becoming a pest during most years. It is a tiny wasplike insect so small that the grub stage feeds inside an individual greenbug. When the grub is full grown the dead skin of the aphid becomes fastened to a leaf, turns brown, and the tiny wasp passes a resting stage inside. A few days later the adult parasite
emerges by cutting a circular lid in the back of the shell. Where the parasite is active, many greenbug "mummies" (Fig. 23), brown in color, may be found attached to wheat leaves. Both the parasites and the predaceous ladybird beetles are present or follow the greenbug as it develops and, if spring temperatures are high enough, control its spread.

Experiments involving rearing and liberating parasites and lady beetles in fields to control greenbugs have been unsuccessful or impractical. If weather conditions are favorable, parasites and lady beetles are usually present in sufficient numbers to control the greenbugs. If the weather is too cool, neither parasites nor lady beetles will feed or reproduce and it is useless to introduce more. Lady beetles introduced into fields from cold storage will quickly climb to the top of the nearest plant and take flight for distant fields.

**Insecticidal Control.**

Insecticides should be used to control greenbug outbreaks when natural or cultural con-

Fig. 23.—(Top) Larva and adult of lady beetle that commonly attacks green bugs on wheat. Magnified approximately 5X. (Center) Pupae or resting stage of lady beetles on wheat leaf. Magnified approximately 5X. (Bottom) Mummies of green bugs parasitized by the minute wasp *Aphidius* (*Lysiphlebus*) *tritici* (*Cressa*). This wasp matures inside the aphid’s body and comes out through a trap door cut in the top of the abdomen. Magnified approximately 7X.
control is inadequate. Parathion sprays or dust give good control. Both sprays and dusts should be applied at the rate of 4 ounces of actual parathion per acre. Metacide, a trade name for a mixture of parathion and the dimethyl homolog of parathion, when used at 4 ounces per acre, also gives good control.

For best results with parathion and Metacide the temperature should be at least 50° F. at the time of application and for at least three hours after. Tetraethyl pyrophosphate (TEP) used at the rate of 4 to 5 ounces per acre will give satisfactory control when the temperature is 75° F. or above.

All three materials are extremely toxic to man and livestock. They should be applied only with power equipment, either aerial or ground. Only skilled and experienced persons using proper precautions should make the application. The following information is provided to guide those who assume full responsibility for use of these three insecticides.

These insecticides are poisonous if swallowed, if inhaled, or if absorbed through the skin. These precautions and those printed on packages of these materials are for your protection.

1. Wash hands, arms, and face after handling these insecticides and before eating, drinking, or smoking.

2. Always wear natural rubber gloves in handling these chemicals; never use synthetic rubber, leather or cloth gloves.

3. Avoid breathing sprays or dusts. Always work to windward. While handling these materials, when spraying or entering sprayed areas, wear suitable respirators (which the manufacturer definitely states are designed for protection against TEP, parathion, and other similar insecticides). Replacement cartridges and filters are available and should be on hand and used as directed.

4. Wear goggles and protective clothing whenever these materials are used. A light plastic raincoat gives good protection. Wear a washable rubber or plastic rain hat. Clothing that has been contaminated with these materials should be removed immediately and washed in soap and water before reuse.

5. Permanently dispose of containers so that they cannot be used for any other purpose.

Atropine is the emergency antidote for parathion poisoning and is obtainable only on a doctor's prescription. The doctors in your neighborhood should be informed regarding the symptoms of parathion poisoning and the treatment shown below. Consult your doctor and arrange with him for a prescription of atropine grains 1/120 (0.5 mg.) to be kept on hand for emergency use. Never take atropine or any similar drug until AFTER warning symptoms appear. The symptoms of parathion poisoning include head-
ache, blurred vision, weakness, nausea, cramps, diarrhea, and discomfort in the chest. If you feel any of these symptoms while using parathion, quit work, take two atropine tablets at once, and go to a doctor. Do not use parathion or other organic phosphorous insecticides until your doctor has examined a blood sample for parathion effect (until regeneration of blood and tissue cholinesterase is complete).

Flight operators should familiarize themselves thoroughly with Civil Aeronautics Administration, Aviation Safety Release No. 325, issued August 26, 1949.

In airplane dusting or spraying operations, the parathion respirator is satisfactory for flagmen or handlers and loaders of these insecticides. Pilots should wear full-face masks which the manufacturer definitely states are designed for protection from TEP, parathion, and other organic phosphorous insecticides.

NOTICE TO PHYSICIANS:

ANTIDOTE

External: Skin: Immediately remove all contaminated clothing and wash skin thoroughly with soap and warm water. Eyes: Immediately flush with water for at least 15 minutes.

Internal: Give tablespoonful of salt in glass of warm water and repeat until vomit fluid is clear. Never give anything by mouth to an unconscious person. Have patient lie down and keep warm. Atropine is antidotal; never give morphine. Give atropine grains 1/60 to grains 1/30 (1 or 2 mg.) every 15 minutes to one hour until pupils dilate. It is advantageous to give atropine intravenously, depending upon seriousness of condition. Clear chest by postural drainage. Give artificial respiration if breathing stops, or becomes weak or irregular.

Wheat should not be pastured for at least three days after applying tetraethyl pyrophosphate or 15 days after the use of parathion or Metacide.

The amounts and kinds of insecticides to be recommended change frequently as new and better methods are discovered through research. For latest recommendations consult the Department of Entomology or the extension entomologist, both at Kansas State College, Manhattan, or the county agent.

CUTWORMS AND ARMYWORMS

There are several species of cutworms that injure growing wheat plants in Kansas, but only a few are really destructive. The species involved are grass-inhabiting insects. Their abundance depends to a considerable extent on temperature and rainfall of the fall and late summer preceding the outbreak. Some species, like the army cutworm, are surface feeders; others, like the pale western cutworm, are wholly underground in habit. Others, such as the army-

16. Chorizagrotis auxiliarus (Grote).
17. Agrotis orthogonia (Morrison).
worm\textsuperscript{18} and the variegated cutworm,\textsuperscript{19} are climbing species.

Cutworms have four stages in their life cycle. The adult is a moth or "miller," other stages are egg, larva (or cutworm), and pupa. Larvae that feed above ground often are heavily parasitized by flies and wasps, for some degree of natural control.

Description of Stages.

Adults. The adults are gray, brown, tan, or dark-colored moths with a wing spread of \(1\frac{1}{2}\) to \(1\frac{3}{4}\) inches. The front wings often have a white, silvery, kidney-shaped or circular silvery-white spot or mark on the upper surface. The moths are active at night and often fly to lights in large numbers on warm nights about three weeks after cutworm outbreaks. They hide during the day under boards, behind bark, or near the soil under dense clumps of grass. They shun the light and fly only short distances to hide when disturbed during the day. A female may lay 300 to 400 eggs.

Egg. The eggs may be laid singly at the base of plants, on the soil, or in plowed, cultivated soil. Many eggs may be deposited within a small area. Some species deposit their eggs in masses. Hatching time may vary from 10 to 15 days or several months, depending upon the rainfall and temperature.

Larva. Eggs of army cutworms (Fig. 24) are laid late summer or early fall at the base of plants or on the soil in grassy areas, in pastures, along roadsides, in grassy ravines, in borders of fields, or in the wheat fields. The eggs hatch within 10 to 15 days, but since egg laying covers a considerable period of time, the larvae will vary in size from small worms to those almost three-fourths grown by the time the fall temperatures cause the worms to stop feeding. Since the larvae are so small and plenty of green vegetation is available in the fall, they do not injure wheat in the fall. As the soil becomes cool the larvae burrow a few inches below the surface to spend the winter. As soon as the frost goes out of the soil in the spring, they return to the surface, resume feeding, and complete their development. It is during early spring that major damage may occur. These sluggish, brown larvae curl up when disturbed (Fig. 24).

Cutworms feed at night or on cloudy days. They are most active during warm nights following warm afternoons. Cold, late springs prolong the feeding period of the larvae, and also prevent rapid growth of the wheat plants. This results in considerable injury to the crop.

The pale western cutworm is gray with no stripes, spots, or other conspicuous markings. Its skin appears to be covered with granules.

Armyworms (Fig. 24), when small, crawl in a looping man-
ner like a measuring worm. They have a general greenish appearance, marked with a pattern of stripes. A wide, broken, longitudinal stripe extends down the back. Pale orange, longitudinal stripes, bordered with white, are on the sides.

Variegated cutworms are grayish-brown, with a pale yellow dot on the top of the first seven body segments. A conspicuous dark W is often present on the eighth abdominal segment.

**Pupa.** When the larvae reach their full development, they burrow into the soil 3 or 4 inches, form a small earthen cell, and transform to a mahogany brown pupa. The pupa changes within two or three weeks to a moth, and escapes to the surface through the burrow made when it entered the soil to pupate. The variegated cutworm overwinters as a pupa. The moth comes out, lays eggs, and the larvae become active in June.

Most cutworms have but one generation each year. The armyworm and variegated cutworm may have two or more generations each summer.

**Description of Injury.**

**Injury by the army cutworm.** The chief damage by army cutworms is in the early spring when the young wheat plants

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**Fig. 24.**-(Top 5) Army cutworms showing variation in size and color. Magnified about 1 1/4 X. (Bottom 3) Larvae of army worm slightly reduced. These larvae feed on leaves, less commonly on heads. They are especially common in fields where wheat has lodged.
are beginning spring growth. Since this species of cutworm is capable of feeding when the temperatures are slightly above freezing, if it is abundant, it causes considerable damage to winter wheat.

The worms cut off new tillers and leaves at slightly below or above the surface of the soil, often below the accumulation of leaves killed by winter. During cold days larvae may be found about 1 inch below the surface of the soil, in the loose soil between the drill rows. Occasionally, in cold weather, the larvae will cut off a tiller or leaf and pull one end of it into the burrow and feed. The wheat plants often look as if they had been grazed close to the surface. Usually dead leaves and tillers are found near the grazed plants, indicating the presence of cutworms.

**Injury by the armyworm.** Armyworms are really climbing cutworms that attack wheat about the time it is heading. They feed on the leaves, kernels, and beards of the heads (Fig. 25), and often cut off the heads. Since larvae feed during the day as well as at night, they may be observed on the wheat plant, feeding in groups of several to a plant.

**Injury by the pale western cutworm.** This species feeds

![Fig. 25.—Beards and parts of spikelets cut from heads of green wheat by army worm. This type of damage is oftener done by wheat head army worm.](image-url)
entirely underground and cuts off developing wheat plants in the spring, about 1 inch below the surface. The moths of this species deposit eggs on loose, cultivated soil. If the soil is dry, the eggs may not hatch until late fall.

The larvae follow the drill rows and seldom come to the surface, except when the soil becomes saturated with water following heavy rains. They may injure wheat in the three western tiers of Kansas counties.

Control of Cutworms.

1. Clean culture, which reduces the number of grassy areas such as roadsides and swales, may help prevent cutworm injury.

2. Apply dieldrin or aldrin in sprays at $\frac{1}{4}$ to $\frac{1}{2}$ pound of actual insecticide per acre. One pint of 25 percent aldrin or dieldrin is usually formulated to contain $\frac{1}{4}$ pound actual insecticide; or

3. Apply toxaphene, $1\frac{3}{4}$ to 2 pounds of actual insecticide per acre; or

4. Apply DDT, 2 pounds of actual insecticide per acre. One gallon of 25 percent emulsifiable concentrate is usually formulated to contain 2 pounds actual DDT.

Sprays are most effective when applied in late afternoon on warm days, when the greatest number of cutworms is feeding at the surface of the soil. Wheat should not be grazed by livestock for 15 days after spraying with aldrin, 30 days after applying dieldrin, 21 days after applying DDT, or 40 days following toxaphene application. Straw from wheat sprayed for the control of armyworm or climbing cutworm should not be fed for similar periods after being sprayed.

Usually no control measures are necessary for the pale western cutworm. Since this species feeds entirely underground, it will be necessary to treat the soil with $\frac{1}{2}$ pound of aldrin or dieldrin to the acre, applied before the wheat is sowed, and cultivated into the first 6 inches of the soil.

WHEAT MITES

Brown Wheat Mites.20

The brown wheat mite is a serious pest of dryland wheat in western Kansas, occasionally occurring in abundance as far east as Herington. Damage by this mite occurs only during dry weather and is similar to drought damage. Wheat suffers from loss of plant juices withdrawn by the mites as food, and heavily infested plants appear to be dried out, even though sufficient moisture is within reach of the plant roots. A fine mottling of the leaves occurs and, when seen at a distance, a bronzing or yellowing effect may be observed. This mite does not spin webs as some other spider mites do.

The rounded, metallic dark-brown or blackish body about the size of a comma in ordinary newspapers, with short hairs on the upper side, serve for hand-lens identification in

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20. *Petrobius latens* (Muller).
INSECTS THAT ATTACK WHEAT 39

Fig. 26.—The adult brown wheat mite. From a drawing of Baker and Pritchard (1953). Magnified about 50X. Courtesy, The Division of Agriculture, University of California.

the field (Fig. 26). The legs are pale yellowish, and the fore legs are characteristically longer than the other three pairs of legs.

Brown wheat mites pass the summer as extremely small, shiny, white eggs. Large numbers of these eggs may be found in the soil and at the base of plants, attached to the undersurface of bits of debris and clods of soil. The eggs are coated with a white, waxy material and one end is flattened in a circular area somewhat larger than the diameter of the egg itself. To hatch, the eggs must be in contact with free moisture. So long as dry whether prevails, no hatching occurs. But as soon as there is enough moisture to germinate either volunteer or seeded wheat, hatching begins. Young mites are bright red-orange and have three pairs of legs. As soon as they feed they become a deep brownish color. The next two stages have four pairs of legs and closely resemble the adults in color. It takes eight to nine days for the mites to reach the adult stage and one to two days later they begin to lay eggs. During the fall, winter, and early spring the eggs are brick red and lack the waxy coating of the summer eggs. The winter eggs hatch in six to seven days under favorable circumstances, and each adult lays from 70-90 eggs in three weeks. Males are unknown in this species; the eggs hatch without fertilization. During late spring certain adults begin to lay the summer-type eggs with the waxy coating, laying approximately 30 eggs in three weeks. With this high reproductive capacity it is not surprising that damaging numbers occur in fields that only a few weeks before had low populations. Heavy rains will almost entirely eliminate this mite.

Besides wheat and other small grains, brown wheat mites have been reported feeding on ryegrass, iris, gladiolus, sorghum, alfalfa, burclover, moss, onions, and carrots. They sometimes invade houses.

A crop rotation with wheat
planted every third year may be used to lower mite populations. Damage to summer-fallow wheat is less severe than damage to continuously cropped wheat.

Controlling this pest by chemicals is difficult. The most practical material tested is ½ pound parathion per acre. It does not always result in good control. If aerial application is made, at least 2 gallons of diesel oil per acre should be used as a carrier. When water is the diluent, use at least 6-8 gallons of water per acre, as in control of the greenbug with parathion.

SEE PAGE 33 FOR PRECAUTIONS IN APPLYING PARATHION.

The amounts and kinds of miticides to be recommended change frequently as new and better methods are discovered through research. For latest recommendations consult the Department of Entomology or the extension entomologist, both at Kansas State College, Manhattan, or the county agent.

The winter grain mite21 is similar to the brown wheat mite in appearance, habits, and damage but has an orange spot on top of the body. It has been reported in a few areas in east-central and southeastern Kansas. It appears earlier in the spring than the brown wheat mite. No control tests have been reported in Kansas, but parathion, malathion, and several other poisons have been used successfully in tests against the winter grain mite by U. S. Department of Agriculture men in Texas.

The white spider mite22 differs from other mites found in the field on wheat, since it spins fine webbing on the leaves. In Kansas this mite has been found on volunteer; less commonly on seeded wheat. The mites are yellowish or whitish, about half the size of the brown wheat mite. Except for the webbing, damage done by the white spider mite is similar to that done by the brown mite and is worse during dry periods.

Early in the spring of 1953 it was shown by J. T. Slykhuys,

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21. Penthalenus major (Duges).
22. Paratetranychus pratensis (Banks).
a Canadian working in South Dakota, that the wheat curl mite\textsuperscript{23} (Figs. 27, 28) was re-

\begin{itemize}
\item\textbf{23. Aceria tulipae (K.)}
\end{itemize}

\begin{figure}[h]
\centering
\includegraphics[width=0.8\textwidth]{fig28.jpg}
\caption{Wheat curl mite, \textit{Aceria tulipae} (K.) at base of wheat leaf near ligule. Magnified approximately 10X.}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=0.8\textwidth]{fig29.jpg}
\caption{The three leaves on the right show the folding of one edge characteristic of injury by wheat curl mite near heading time of wheat. On left normal wheat leaf.}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=0.8\textwidth]{fig30.jpg}
\caption{Beards trapped by curling of leaves as the result of work of wheat curl mites, which carry wheat-streak mosaic. This same type of injury, including the rolling of leaves, also may be caused by hail or green bug. Uninjured head at left.}
\end{figure}

sponsible for transmitting the wheat-streak mosaic\textsuperscript{24} that caused severe damage to wheat in western Kansas in 1949 and 1954. Transmitting mosaic is the reason for the importance of this mite; other damage done by it is barely evident and consists of slight curling and folding of the leaves (Fig. 29) or trapping beards (Fig. 30). Greenbugs, white spider mites, and other agencies also can cause this same type of injury but do not transmit the disease. The wheat curl mite is white, spindle-shaped, with only four legs near the anterior end of the body (Fig. 27). These mites are so small they

\begin{itemize}
\item For information on wheat streak mosaic see Bulletin 368.
\end{itemize}
are barely visible magnified 10 times. Ordinarily they are found on the upper leaf surface and in the whorl. They pass the summer between wheat crops on volunteer wheat and various grasses, especially western wheatgrass. Western wheatgrass is immune to mosaic. It does not serve as a source of the disease for transmission by mites to the new wheat crop. Mites may be present on wheat without causing transmission of mosaic.

Eggs are laid in the grooves of the wheat leaf and similar grooves of the western wheatgrass leaves. The mite passes the winter well down in the crown and behind the leaf sheaths.

Destruction of volunteer wheat and weedgrasses, as soon as they come up after harvest, will decrease the numbers of mites and amount of mosaic that can be carried to the newly seeded wheat the following fall.

WHEAT INSECTS USUALLY NOT REQUIRING CONTROL MEASURES

Besides the principal insects damaging wheat, many others can be found on wheat at various times in some localities. Only rarely has it been necessary to use control methods with them. Other insects have attracted attention or been confused with more important insects. Hence they are discussed briefly here.

CHINCHBUGS, Blissus leucopterus (Say). Chinchbugs (Fig. 31) normally are found in the eastern one-third to one-half of Kansas. The adult, foul-smelling, black and white chinchbugs are about 1/6 inch long. In early spring they fly to wheat and other small grains from the bunchgrass, where they pass the winter. The bugs are found in the thinner parts of the fields where they lay eggs behind the wheat leaf sheath near the surface of the ground. The eggs hatch into tiny, active red nymphs that feed on the developing wheat. If extremely abundant, they may stunt wheat or cause it to die in small areas. When the wheat is harvested, the nymphs and the few adults move on foot to the nearest corn or sorghum field, where severe damage may be done to small row-crop plants. Ordinarily it has not been economical to control chinchbugs on wheat chemically.
The \textit{Wheat Strawworm}, \textit{Harmolita grandis} (Riley), usually is seen as a small greenish-yellow larva inside the wheat stem and just above the top joint. There it feeds on the pith of the inside of the straw but rarely reduces yields. Infestations of this insect in Kansas have decreased with widespread use of wheat varieties that mature earlier than the Turkey and Blackhull wheats formerly grown. Combines have eliminated strawstacks, formerly an important source of infestation by wheat strawworms.

The \textit{wheat strawworm} passes the winter in the straw, emerging in February and March as a shiny black, ant-like, wingless insect. Most of them are females that lay eggs in the young wheat plants. Larvae that hatch feed on the developing head. The wall of the short stem around the larvae enlarges and hardens, forming a gall and eventually killing the tiller that is attacked.

The second-generation adult that emerges from this gall looks like a winged ant and lays its egg in the wheat stem when the wheat head is in the boot. In eastern Kansas an effective control is to plant wheat 65 to 75 yards from the nearest straw or stubble of the preceding year. Since the adult of the first generation is wingless, it does not travel this far and is unable to infest the young wheat. Thorough plowing under of stubble and clean summer fallow also reduce the populations of this insect.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig32.png}
\caption{(Top) Larva of wheat stem maggot and typical damage that occurs above the top node of the stem, causing white heads as in Figure 33. Magnified approximately 2\%X. (Bottom) Adult fly of wheat stem maggot. Note enlarged hind femora. Magnified approximately 15X.}
\end{figure}
The WHEAT STEM MAGGOT, *Meromyza americana* (Fitch) (Fig. 32), attracts attention when the wheat is in bloom because conspicuous white heads (Fig. 33) result from infestation by this insect. White heads caused by the wheat stem maggot always occur singly; the flag leaf is usually green, contrasting strongly with the white head and straw above, and the stem is loose in the upper leaf sheath. The active greenish-yellow maggot, 1/4 of an inch long, often may be found above the top joint of the stems with white heads. This is the larva of the first spring generation. Two or three other generations may occur on volunteer wheat or grasses before the insect passes the winter as a larva in the tiller of a volunteer or fall-sown wheat plant. Larvae infesting wheat in the fall and late summer kill the young plant or tiller infested.

Although potentially a dangerous insect, heavy infestations of wheat stem maggots have not been seen in Kansas. The spring infestation has been reduced by the increasing acreage of recently introduced, early-maturing wheat varieties. Fall infestations may be reduced by planting at the time recommended to escape infestations of hessian flies. By the time white heads are visible in wheat, damage already has been done and no control of the insects in that crop is possible.

The COMMON STALK BORER, *Papaipema nebris* (Guen), is sometimes responsible for white heads along the margins of wheat fields just before the crop begins to ripen. While such white heads have frequently caused alarm, the in-

![Fig. 33.—Extreme left, white wheat heads caused by feeding of the wheat stem maggot just above the top stem node. Note that the flag leaf is green. Compare normal heads of same age just right of the white heads. Right picture shows holes in wheat stem caused by feeding of the common stalk borer. Often the heads from such stalks turn white, as with wheat stem maggot.](image-url)
sects causing them are ordinarily not sufficiently abundant to require control. Injury by the stalk borer may be recognized by a hole (Fig. 33) about 1/4 inch in diameter low down in the culm. Often the caterpillar will be found tunneling in the culm. It is about 1 inch long, dark brown, with a continuous white stripe down the center of the back, and white stripes on each side broken by patches of brown near the front part of the body just behind the true legs (Fig. 34). The common stalk borer feeds on many plants, especially giant ragweeds. It usually damages crop plants such as corn and oats, as well as wheat, but only near the field margins where the borers migrate out of the weeds of the fence row.

The LESSER CORNSTALK BORER, *Elasmopalpus lignosellus* (Zell), has occasionally been found feeding in the crowns of volunteer wheat, where the active larvae make tunnels lined with a few strands of sil: It has been more common in planted wheat in Oklahoma and Texas.

FLEA BEETLES, *Chaetocnema* spp., occasionally cause serious damage to the edges of wheat fields, particularly near grassy fence rows, in the fall. These quite small, shining black beetles jump readily when approached. They feed on wheat leaves, occasionally eating small holes in them. The plants become bleached and die when heavily infested. Control can be obtained by applying 2 pounds of DDT per acre to infested areas.

More than 20 different kinds of LEAFHOPPERS have been collected on wheat. Most of them have been attracted to wheat fields late in the fall or early in the spring when wheat is the principal plant that is still green. Most species stay only a short time on

![Fig. 34. (Top) Larva of common stalk borer that is sometimes found burrowing into wheat stems and causing individual white heads. Magnified about 1 1/2 X. (Center) The leafhopper, *Endria imicina* (Say), that frequently breeds on wheat. Magnified approximately 12X. (Bottom) Adult of one of the wheat leaf feeding sawflies. Magnified approximately 3 1/2 X.](image-url)
wheat and do little damage. They may be mistaken for other insects, such as the hessian fly. A few leafhoppers are able to breed on wheat, and one, the painted leafhopper, *Eudia inimica* (Say) (Fig. 34), is known to carry a type of mosaic that so far (1954) has been rare in Kansas.

At least five species of leaf-feeding sawflies, *Genus Pachynematus* (Fig. 34), have been collected or reared on wheat in Kansas. All five are green caterpillarlike larvae (Fig. 35) without prolegs under the abdomen and with a single black eye on each side of the head. The life cycle requires one or two years for its completion and the larvae have been heavily parasitized. They have never become sufficiently abundant in Kansas to require control measures.

At least 18 different species of thrips have been collected on wheat—oftener on volunteer wheat—in Kansas. Some of these insects are predaceous, feeding on other thrips or mites, while most are primarily plant feeders. Only one, *Prosopothrips cognatus* (Hood) (Fig. 36), has been seen severely damaging seeded wheat. It is about 1/16 of an inch long, wingless, with a black head and thorax, and an orange-red abdomen. It causes wheat foliage to turn whitish
or rusty and, when abundant, injures the flowers and grain. Various grasses provide alternate hosts during the summer. Observed injury was in central Kansas. Since the species is wingless, rotation, destruction of volunteer and weed-grasses, and summer fallow have served to keep its populations satisfactorily low. There has been no opportunity to test the newer insecticides, but DDT, BHC, and others have given successful control of thrips on other crops and should be satisfactory should insecticidal control become necessary.

**SUMMARY**

Among the number of insects and mites that attack wheat, there are some that are frequently destructive, while others rarely cause damage of economic importance. Since many of these destructive pests are carried over the summer on volunteer wheat, the destruction of volunteer is an important way to prevent outbreaks. Other means of reducing insect injury in general include such good farm practices as rotation, summer fallow, proper time of planting, and timeliness in control operations. In general, prevention is less costly than treatment after an infestation develops.

Information is given in this bulletin on life history, distinguishing characteristics, and control of false wireworms, true wireworms, white grubs, rootworms, grasshoppers, hessian flies, greenbugs, and other aphids, cutworms, armyworms, wheat mites, chinchiugs, wheat strawworms, wheat stem maggots, leafhoppers, thrips, and other insects attacking the growing wheat plant.

Since newer and better methods of control of mites and insects are continually being found through experiment station research, information on the most recent improvement may be obtained from the Department of Entomology or the extension entomologist, both at Kansas State College, Manhattan, or the county agricultural agent.
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