# AGRICULTURAL INSECT PEST TRAINING MANUAL





STATE OF MONTANA
DEPARTMENT OF AGRICULTURE
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# PREFACE

This manual is intended as a study guide for applicators controlling insect pests in crops. Readers will gain a general knowledge of insect identification, the principles of insect management and the safe use of insecticides. The manual discusses insects that may become pests in each of Montana's common crops and current methods of control are listed.

To simplify information, trade named products and equipment have been mentioned. No endorsement is intended, nor is criticism implied of similar products or equipment which are not mentioned.

We wish to acknowledge the help of personnel of the Environmental Management Division, Montana Department of Agriculture, in preparing this manual.

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CHAPTER I

# INSECT RECOGNITION

## Introduction

Most insects are beneficial. Many are predators like the lady beetle which feeds on aphids. Some may be parasitic on insect pests, while others are important crop pollinators. Of the approximately one million species of insects that inhabit the earth, only a small percentage (less than 1%) are considered pests. However, this small number is capable of causing serious crop losses averaging from 5% - 15% of annual agricultural production. Insect pests may attack the seed, cut off young plants, chew foliage, suck plant sap, bore or tunnel in branches or stems and transmit plant diseases. They may also transmit serious diseases to man or animals.

## Insect Structure

Insects are animals, but unlike most animals we are acquainted with, they have no backbone. Insects have an outer skeleton known as an exoskeleton, rather than the inner skeleton typical of most large animals. The following characteristics also distinguish insects from other animals:

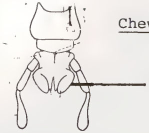
1. Three body regions - head, thorax and abdomen.
2. Three pair of legs on the thorax.
3. One or two pair of wings. (Some have none.)
4. One pair of antennae.


A closer examination of the insect's three body regions will further aid in their recognition.

### Head

The eyes (compound and/or simple), the antennae and the mouthparts are located on the head. The characteristics of the mouthparts and the antennae are useful in insect identification. An understanding of the mouthparts and feeding habits of insects can be helpful in selecting an effective control measure. Insect mouthparts are of two general types, chewing and sucking.

Insects with chewing type mouthparts move their mandibles, or jaws, in a sideways motion.




Insects with chewing mouthparts include the adult beetles, ants, bees, wasps, lacewing flies, dragon and damsel flies, grasshoppers, and crickets. Immature insects such as caterpillers, fly maggots, and beetle larvae also have chewing mouthparts.

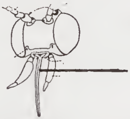
Sucking type mouthparts are highly modified. Insects with this type mouth structure cannot chew their food. Sucking mouthparts are in the form of a somewhat elongated beak through which food is sucked. This type mouth structure may be further modified to be:

1. Piercing-sucking as in the mosquitoes, true bugs and aphids.

2. Lapping-sponging as in the housefly.

3. Rasping-sucking as in the thrips.

4. Tube-like as in the moths and butterflies.




Insects with sucking mouthparts include the adult sucking lice, flies, mosquitoes, true bugs, aphids, scale insects, leafhoppers, moths and butterflies, fleas, and thrips.

Thorax

The thorax is the middle region of the insect body and is divided into three segments. One pair of jointed legs is attached to each of these segements. The legs are often greatly modified in different insect species. They may vary from thin and delicate such as those on a butterfly to thick and powerful for running or grasping prey such as the front legs of a praying mantid. The wings when present are also attached to the thorax. Characteristics of the legs and wings are often useful in insect identification.

Abdomen

The insect abdomen is composed of up to eleven segments. The abdomen usually contains the external reproductive structures and excretory openings. Depending upon the species, the abdomen may have various types of ornamentations, some functional as the cornicles of an aphid, and others simply for looks.

## Insect Development

All insects develop from eggs, most after the eggs have been laid. A few insects develop from eggs within the body of the female and are born alive. Insect eggs vary widely in size and shape. They are usually laid in protected locations that afford the young good conditions for survival.

After hatching, insects develop by passing through a series of growth stages. The size of an insect is restricted by its hard outer exoskeleton. Each new growth stage involves shedding of the old exoskeleton and forming a new one. This shedding process is called <u>molting</u>. The insect stage between molts is called the <u>instar</u>.

As young insects progress towards adulthood, they may change not only in size but also in form. <u>Metamorphosis</u> describes the process of changing from egg to adult. All insects do not progress through the same series of changes. Some insects, like grasshoppers, change very little in appearance from the newly hatched young to the full grown adult. Other insects, like the moths and butterflies, undergo a drastic change in size and appearance, the young seldom resembling the adult form.

There are two general types of metamorphosis in insects:

<u>Simple metamorphosis</u> involves 3 stages, during which the wings (if any) develop externally.

egg nymph adult

<u>Egg Stage</u>: Adults lay eggs during warm periods of the year. Depending on temperature and moisture, the eggs may overwinter and hatch in the spring.

<u>Nymphs</u>: All immature stages of these insects are called nymphs. They look much like the adult but are of a smaller size. Nymphs (naiads if they develop in water) grow by shedding their skin and advancing through a series of instars to the adult form. If wings are present, they are not fully developed until the last molt is complete.

<u>Adult</u>: Adults are fully developed after the last nymphal molt. During this stage mating and egg laying take place and the cycle is repeated. Adults may or may not feed.

<u>Complete metamorphosis</u> involves 4 growth stages and wing development is internal.

Complete metamorphosis

EGG LARVA PUPA ADULT

Egg stage: The same as simple metamorphosis.

Larva: The newly hatched individuals are called larva (larvae, plural). They may be caterpillars, grubs, maggots or worms. Insects in this stage of development seldom resemble the adults. They are voracious feeders, rapidly molting and advancing through several instars.

Pupa: The last larval instar develops into the pupa (pupae, plural) or resting stage. During this time, the insect changes from larva to adult within the confines of a cocoon or pupal case. The last molt occurs at the end of the pupal stage.

Adult: Ultimately, the adult emerges from the pupa. After becoming sexually mature, mating occurs followed by egg laying. Adults may or may not feed. They may be short lived or in a few instances, remain active for several years.

## Insect Classification

A systematic study of the several million plants and animals in the world demands some method of arranging them in groups. Although there are several ways to classify living things, a standard method based on structural parts has been adopted by scientists worldwide. Under this system, the animal kingdom is divided into a dozen or so major groups called phyla. Ten more important phyla are listed in Table 1.

This manual is concerned with animals primarily in the phylum Arthopoda and Mollusca. Each phylum is further divided into Classes, Orders, Families, and Species. Each lower level in this classification scheme more precisely describes a particular animal. Using the common housefly as an example, the classification would be as follows:

TABLE 1. Ten Important Phyla in the Animal Kingdom

| | |
|---|---|
| | Invertebrates |
| 1. | Protozoa - single-celled animals; amoeba |
| 2. | Porifera - sponges |
| 3. | Coelenterata - jellyfishes, corals |
| 4. | Platyhelminthes - flatworms, flukes, tapeworms |
| 5. | Aschelminthes - roundworms, trichina |
| 6. | Mollusca - snails, slugs, clams |
| 7. | Echinodermata - starfish, sea cucumbers |
| 8. | Annelida - segmented worms, earthe worms, leeches |
| 9. | Arthropoda - insects, spiders, crayfish, millipedes |
| | Vertebrates |
| 10. | Chordata - fish, amphibians, reptiles, birds, mammals |

Kingdom - Animal
Phylum - Arthropoda
Class - Insecta
Order - Diptera
Family - Muscidae
Genus - Musca
Species - domestica

Common names of insects often vary for one species from one locale to another. To avoid much of this confusion, a systematic and standardized arrangement of scientific names has been developed. The name of each insect consists of the Order, Family, and Genus which are capitalized, followed by the Species and Sub-species name when applicable. The name of the person who described the species appears last. The genus and species name are underlined and written in italics. A shortened form of the complete scientific name consists of the genus and species.

Example: common housefly
Full Scientific name: Musca domestica Linnaeus (Diptera: Muscidae)
Shortened Scientific name: Musca domestica linnaeus

There are approximately 26 orders of insects. This manual will deal only with those orders containing species considered injurious to plants, animals or humans. Ten such orders are:

Coleoptera - beetles. Adults have two pair of wings (front pair hard and leathery); chewing mouthparts; complete metamorphosis. This group comprises the largest order of insects. Many species are injurious to crops, stored products, structures and household items such as clothes, carpets and books. Examples: Colorado potato beetle, alfalfa weevil, timber beetle, flour beetle, and carpet beetles.

Dermaptera - Two pair of reduced wings; chewing type mouthparts; simple metamorphosis. These insects are general feeders and usually feed at night. They may be found under objects or in cracks and crevices. Example: earwigs.

Diptera - flies and mosquitoes. Adults have two wings piercing-sucking and lapping type mouthparts: complete metamorphosis. This order has many injurious species. Examples: housefly, mosquito, screwworm, apple maggot, Hessian fly.

Hemiptera - "true" bugs. Members of this order have two pair of wings; sucking type mouthparts; simple metamorphosis. This order is similar to the Homoptera and are distinguished primarily by differences in wing structure. Examples: stink bugs, bed bugs, lygus bugs.

Homoptera - May be winged (two pairs) of wingless; sucking mouthparts; metamorphosis variable. Members of this order are plant feeders and may be serious pests of cultivated plants. They are also important transmitters of plant diseases. Examples: aphids, white flies, scales, planthoppers, leafhoppers.

Hymenoptera - ants, bees and wasps. Adults characterized by two pair of wings (except worker ants and bees); chewing mouthparts complete metamorphosis. This order contains beneficial species (pollinators and parasites) as well as some which cause economic damage and human concern. Examples: carpenter ants, wheat stem sawflies, gall wasps, seed chalcids.

Isoptera - termites. Social insects living in colonies. Both winged and wingless forms occur in a colony. Chewing mouthparts; simple metamorphosis. This order may be highly destructive to wooden structures which are not protected.

Lepidoptera - butterflies and moths. Adults have two pair of wings; sucking moughparts; complete metamorphosis. Immature forms (caterpillars) have chewing mouthparts and some are destructive pests of crops, forests and fabrics. Examples: loopers, cutworms, armyworms.

Orthoptera - cockroaches, grasshoppers, crickets and mantids. May be winged or wingless; chewing mouthparts; simple metamorphosis. Winged forms have two pair of wings. Many members of this order are important plant pests.

Siphonaptera - fleas. Wingless; piercing-sucking mouthparts; complete metamorphosis. Fleas are carriers of diseases which may infect man and animals.

# Insect Identification

Proper identification of the pest is essential prior to selecting a proper control method. There are various identification aids available such as pictures, written descriptions and keys. Keys are the best means of identifying organisms of any kind. The following is an example of a couplet key to the major orders of insects based on insect structure. To use such a key, the specimen is examined for the characters described after number 1. A choice must be made and this results in a referral to the next couplet, either 2 or 15 in this case. The process continues until the name of the order is reached.

## KEY TO SELECTED ORDERS OF ADULT INSECTS

1. Wings absent.................................................. 2
   Wings present................................................. 15

2. Sedentary insects, legs usually absent; body scale-like or grub-like and covered with a waxy secretion. (Females of many Coccidae)......................HOMOPTERA
   Not sedentary; with distinct head and jointed legs.......... 3

3. Mouthparts adapted for biting and chewing.................. 4
   Mouthparts not adapted for biting and chewing; piercing-sucking, rasping-sucking or siphoning type................. 9

4. Body covered with scales or mouthparts retracted within the head so that only their apices are visible............. 5
   Body not clothed with scales; mouthparts fully exposed..... 6

5. Abdomen composed of not more than 6 segments; usually provided with a spring near the caudal end; first abdominal segment with a forked appendage (sucked on ventral surface...............................COLLEMBOLA
   Abdomen composed of 10 or 11 segments; the abdomen may terminate in long caudal appendages or immovable forcep-like appendages and the body may be covered with scales THYSANURA

6. Small louse-like insects, usually markedly flattened, soft or leathery in appearance..........MALLOPHAGA
   Not louse-like in form; not markedly flattened; exoskeleton well differentiated................................ 7

7. Abdomen sharply constricted at base......HYMENOPTERA
   Abdomen not sharply constricted at base, broadly joined to the thorax............................................ 8

8. Abdomen with cerci, body not ant-like in form...ORTHOPTERA
   Abdomen without cerci, body ant-like in form....ISOPTERA

9. Mouthparts consisting of a proboscis coiled up beneath the head; body more or less covered with long hairs or scales...............................LEPIDOPTERA
   Mouthparts not as described above; body not covered with long hairs or scales....................................... 10

10. Body strongly compressed; legs nearly always long and fitted for jumping......................SIPHONAPTERA
Body not strongly compressed; legs fitted for running....... 11

11. Mouthparts consisting of a jointed beak (the labium) with which are the piercing stylets.............................. 12
Mouthparts consisting of an unjointed fleshy or horny beak or the beak may be absent.............................. 13

12. Beak arising from the anterior end of the head...HEMIPTERA
Beak arising from the posterior end of the head, apparently between the coxae of the front legs...HOMOPTERA

13. Tarsi with the apical joints terminating in bladder-like enlargements; well defined claws absent; mouth-parts forming a triangular or cone shaped, unjointed beak................................THYSANOPTERA
Tarsi not as described above; with well developed claws..... 14

14. Antennae hidden in pits, not visible in dorsal view; tarsi with 2 claws.........................DIPTERA
Antennae exposed, not hidden in pits, visible in dorsal view, tarsi with 1 claw....................ANOPLURA

15. Two wings present, hindwings represented by halters DIPTERA
Four wings present........................................ 16

16. Fore wings and hind wings similar in texture, usually membranous................................................ 17
Fore wings and hind wings dissimilar in texture, usually wings tickened, leathery or horny, hind wings membranous.... 22

17. Wings entirely or for the most part covered with scales; mouthparts consist of a coiled tube beneath the head, formed for siphoning .....................LEPIDOPTERA
Wings not clothed with scales; mouthparts not as described above.................................................. 18

18. Wings long and narrow with only one or two veins or none; last joint of tarsus bladderlike...........THYSANOPTERA
Wings not as described above; last joint of tarsus not bladderlike............................................ 19

19. Mouthparts enclosed in a jointed beak (labium) and fitted for piercing and sucking; beak arises from the rear of the head apparently between the front coxae...HOMOPTERA
Mouthparts not enclosed in a jointed beak; not arising from the rear of the head................................. 20

20. Wings with few longitudinal veins, not net-veined or they may be veinless............................HYMENOPTERA
Wings with many longitudinal veins and cross veins, appearing net-veined (12 or more cross-veins)............... 21

21. Antennae short, setiform or setaceous .......ODONATA
Antennae longer, not setiform or setaceous....NEUROPTERA

22. Mouthparts adapted for chewing and biting................... 23
Mouthparts adapted for piercing and sucking................. 24

23. Front wings horny or leathery, lacking veins (elytra) COLEOPTERA
Front wings parchment-like with a network of veins (tegmina) ORTHOPTERA

24. Fore wings thickened at base, membranous and generally overlapping at the tips (hemelytra); beak-like mouthparts arise from the anterior end of the head...........HEMIPTERA
Front wings not thickened at base, uniform in texture, not overlapping at tips; beak-like mouthparts arise from the posterior end of the head apparently between the fore coxae........................................HOMOPTERA

Table 2 is an example of a descriptive key. This key covers six common economic orders of insects. Descriptions of both adult and immature stages are included.

TABLE 2

INSECT IDENTIFICATION

Most Common Economic Orders

| ORDER | | MOUTH PARTS | LEGS | WINGS | EYES |
|---|---|---|---|---|---|
| *COLEOPTERA* (beetles) | ADULT | Chewing | 3 pair on thorax | 2 pair: 1 hardened, 1 membranous | Compound eyes only |
| | LARVAE (Immature) | Chewing | Thorax only (occasionally legless) | None | Simple eyes only; one to six pairs of ocelli |
| *DIPTERA* (flies) | ADULT | Lapping, sponging, or piercing | 3 pair on thorax | 1 pair membranous, 1 pair halteres (tiny stubs that are reduced wings) | Compound and simple. Ocelli three arranged in triangle |
| | LARVAE (Immature) | Chewing, (may be mouth hooks) | None | None | Absent in the maggot forms of higher flies |
| *HEMIPTERA* (true bugs) | ADULT | Sucking | 3 pair thorax | 2 pair: outer leathery with membranous tips, inner membranous | Compound and simple |
| | NYMPHS (Immature) | Sucking | 3 pair thorax | None | Compound and simple |
| *HOMOPTERA* (aphids. scales, etc.) | ADULT | Sucking | 3 pair thorax; (scales may be legless) | 2 pair, in some cases-membranous | Compound and simple |
| | NYMPHS (Immature) | Sucking | 3 pair thorax | None | Compound and simple |

INSECT IDENTIFICATION - Page 2

| ORDER | | MOUTH PARTS | LEGS | WINGS | EYES |
|---|---|---|---|---|---|
| *HYMENOPTERA* (bees--wasps) | ADULT | Chewing or occasionally lapping | 3 pair on thorax | 2 pair, both membranous | Compound and simple. Ocelli three, arranged in triangle |
| | LARVAE (Immature) | Chewing | Thoracic; also abdominal in sawflies but lacking crochets | None | Simple eyes or ocelli only |
| *LEPIDOPTERA* (butterflies--moths) | ADULT | Sucking | 3 pair on thorax | 2 pair, membranous but covered by small scales | Compound and simple, usually 2 ocelli |
| | LARVAE (Immature) | Chewing | Thoracic; abdominal with crochets (hooks) | None | Simple eyes only. Ocelli arranged in 2-6 pairs |

Another method of insect recognition useful to the layman involves an examination of the damage done by the pest. A general determination of the pest type can often be made based on the nature of the feeding damage. Table 3 describes common types of feeding damage.

TABLE 3
TYPES OF INSECT INJURY
(Dependent upon Mouthparts)

Damage from chewing insects

Defoliators - Those pests which chew portions of leaves or stems, stripping or chewing the foliage of plants. Examples: leaf beetles, caterpillars, cutworms, grasshoppers, flea beetles.

Borers - Those pests with chewing mouthparts which bore into stems, tubers, fruit trees, etc. Examples: corn borer, white grub - potatoes, granary weevil - grains, codling moth - apple.

Leaf Miners - Those pests that bore into and then tunnel between epidermal layers. Examples: leaf miners, bark beetles, wood borers.

Damage from piercing and sucking insects

Distorting plant growth - Those pests that cause leaves fruits or stems to wilt, curl or become distorted. Examples: aphid injury, cat facing of peaches from lygus bugs, cone gall on spruce.

Causing stippling effect to leaves - Those pests that may cause many small discolored spots on the leaves which eventually turn yellow. Example: spider mite injury.

Causing burn on leaves - Those pest that secrete toxic substance in the host tissue, causing foliage to appear burned. Examples: leafhopper injury (hopper burn), greenbug injury.

## CHAPTER II

## PESTS RELATED TO INSECTS

### Classification

There are invertebrates, other than insects, which are also pests of man, animals, or plants. They are divided into the following Classes within the phylum Arthropoda.

Arachnida - mites, ticks, spiders and scorpions. Characterized by two body regions (cephalothorax and abdomen), four pair of legs, no antennae or wings.

Chilopoda - centipedes. Characterized by being long, flat and worm-like. Fifteen or more pair of legs, one pair to each body segment. The appendages of the first body segment behind the head are jaw-like and poisonous. These jaws are used to paralyze prey.

Crustacea - crabs, crayfish, lobsters, shrimps, and sowbugs. Characterized by two main body regions, two pair of antennae and five or more pair of legs. They live in or near water.

Diplopoda - millipedes. Characterized by being cylindrical and worm-like, two pair of legs per body segment and one pair of antennae.

### Development and Biology

#### Diplopods, Chilopods and Crustaceans

Members of these groups undergo a form of simple metamorphosis. Eggs hatch to nymphs which eventually grow to adults. There are a few subtle differences between groups. Newly hatched millipedes (Diplopods) have only three pair of legs. The additional pairs develop through successive molts. Centipedes (Chilopods) may lay eggs or give birth to living young. Sowbugs (Crustaceans) develop from eggs and resemble the adult from time of hatching. Sowbugs and millipedes are occasionally pests of cultivated plants. Centipedes are generally predaceous scavangers.

#### Arachnids

### Mites

Mites undergo a form of simple metamorphosis. Eggs may be deposited or in a few species, live young are deposited. The first immature stage (larva) usually has six legs, the forth pair developing after the first molt. There may be one or as many as four active nymphal stages.

Mites are smaller than ticks, lack the leathery skin. The tracheal openings, if present, are located near the head or the bases of certain legs. Many mite species are important agricultural pests attacking crop plants or domestic animals. They, too, have sucking mouthparts used to extract plant juice or blood depending upon the host. Some mites are beneficial predators of pest mites and other insects.

Mites may be divided into three economically important groups.

Acaridae - cheese, mange, itch, feather, mites important as animal parasites

Eriophyidae - blister and gall mites - microscopic in size, injurious to wide variety of plants. Cause blistering and russeting of fruit and leaves.

Tetranychidae - spider mite complex. This group includes species very injurious to fruit and field crops. Examples: two-spotted spider mite, clover mite.

Ticks

Ticks can be distinguished from mites by their large size, leathery skin and the presence of spiracles (breathing holes) behind the third or fourth pair of legs. Ticks are economically important pests of livestock and poultry. Their blood sucking activity can reduce the vigor and general health of an animal. Ticks may also transmit disease organisms to animals and man alike.

Ticks lay their eggs in places other than on the host. Upon hatching, the young tick seeks out a host. Like mites, ticks pass through a larva (seed tick), nymph and adult stage. There are usually three instars.

Ticks are represented by two families in North America:

Ixodides - hard ticks. This group of ticks may be identified by the shield found on the back portion of the body and the anteriorly protruding mouthparts. The best known member of this group is the common wood tick, Dermacentor andersoni, which is the vector of Rocky Mountain spotted fever. Others include the brown dog tick, Rhipicephalus sangiuneus, and the lone star tick, Amblyomma americanum, a serious pest of cattle in the South.

Hard ticks take only one blood meal from their host in each of the three instars. They may remain on the host for several days while feeding, but usually drop off to molt. Hard ticks generally have only two or three hosts during their development.

Argasidae - soft ticks. The soft ticks lack a shield on the back and the mouthparts are ventrally located and not visible from above.

Soft ticks usually hide in crevices during the day and feed on their host at night, with each instar feeding several times. Soft ticks may have several hosts during their lifetime. The fowl tick is a common pest in this group.

## CHAPTER III

## PRINCIPLES OF INSECT CONTROL

### Introduction

Insect populations are held in check by a number of limiting environmental factors including weather, host availability, host acceptability, parasites, predators and disease. When these limiting factors are insignificant or at low levels, an insect pest population is often able to take advantage of its adaptability and high reproduction capacity. It is under these conditions that a pest outbreak occurs.

Agricultural cropping systems are especially susceptible to insect pest outbreaks. There is usually an unlimited supply of host material readily available to the pest. Under favorable weather conditions the pest is able to reproduce, often at an astonishing rate. Left to "natural" factors, natural enemies of the pest would ultimately "catch up" to the pest and cause a decline in the outbreak. Often, a considerable lag period occurs between pest buildup and natural enemy buildup. During the lag period, considerable economic damage to the crop may be inflicted.

It is within this buildup stage that control alternatives should be considered in an orderly fashion. A number of "Steps to Pest Control" can be outlined that will help to ensure an effective solution to a pest problem.

1. <u>Detection</u> - It is necessary to be on the lookout for pests likely to be troublesome to a certain crop. It is important to detect infestations early before economic damage is done. Usually this cannot be done through the windshield but requires careful examination of the field. Areas threatened by new pests moving in from adjacent areas may require special detection methods.

2. <u>Identification</u> - A pest must be accurately identified before it can be effectively controlled. Often the most abundant insect in a field is not the one causing the damage. Collect and submit to your area Extension Specialist insects you believe to be a pest. Since many control measures are quite specific to a pest, a thorough approach in the beginning could save time and money in the end.

3. <u>Biology and Habits</u> - Knowledge of the insect's seasonal cycles is important in order to pinpoint the

most effective time of treatment. Proper timing of the treatment to the most vulnerable life stages of the pest will ensure the most effective and economical control.

4. Economic Significance - Pest control activities have both an economic and environmental impact on the grower and his crops. Treatments for agricultural pests should be made only when potential or real economic damage by the pest outweighs the costs of treatment. For many pests, "economic thresholds" have been defined for some crops. Treatment for alfalfa weevil, as an example, is not normally justified at levels below 20 larvae per sweep of a 15" sweep net. Further research is required to determine similar levels for other crop pests.

5. Selection of Methods - After the pest problem has been identified, the life history and seasonal cycle understood, and the economic significance has been established, the proper method or combination of methods can be selected to do the most effective, practical, economical and safe job of control.

6. Application - The control methods selected must be applied properly in order to be effective and safe. If the method involves the use of chemicals, the application must be done at the proper time, at the correct rate and using suitable equipment. The choice of equipment may depend upon the type of chemical formulation used, as well as the intended crop and pest target. This information is available on pesticide labels and in written recommendations.

7. Evaluation - It is important to evaluate the results of the control operation. This can be done in several ways; insect counts before and after treatment, comparative damage ratings, yield data, etc. In most cases it is difficult, if not impossible, to do an adequate evaluation without pre-treatment counts or untreated check areas to use as a basis for comparison. The results of the control operation should be recorded for future reference.

8. Recording - Records provide the basis for gaining from past experiences. It is especially important to record all chemical applications, including chemical formulation, dates, chemical and carrier rates, target of application, crop, and result of the treatment.

## Methods of Insect Control

Methods of insect control have evolved with agriculture over the past centuries. Each new crop developed in an area soon brought with it a new battery of insect pests. Handpicking and beating were among the earliest insect control tools. Over the ensuing generations such "primitive methods" were augmented by the highly sophisticated chemical methods in use today. Below are listed several categories of insect control methods. Each is discussed more fully in Chapter 4.

1. Physical/Mechanical - includes the use of traps of various kinds, handpicking, jarring, collecting, light, sound and electrical barriers or traps, alteration of temperature or humidity.

2. Cultural - includes various tillage methods, crop rotations, planting of resistant or pest tolerant varieties.

3. Legal - involves the establishment of quarantines, or "insect-free" districts, to prevent pest introduction into or spread from a particular area.

4. Chemical - includes the use of insecticides to kill the pest, repellants, attractants, and chemo-sterilants.

5. Biological - involves the use of the pest's natural enemy complex, i.e. parasites, predators, pathogens, or genetic manipulations of the pest population, e.g. sterile-male technique.

6. Integrated Pest Management - involves the best combination of the above methods in a management approach designed to keep the pest at sub-economic levels.

## CHAPTER IV

## INSECT CONTROL TACTICS

As outlined in Chapter 3, there is a wide variety of insect control methods. These methods may be used singly or in combination depending upon the situation and the availability of materials. Currently, there is much interest in developing an "integrated" approach for the major crop pests. Chapter 4 will serve to discuss each of the insect control methods and illustrate how these "tactics" might be combined in an integrated program.

### Physical/Mechanical Methods

This group includes some of the oldest control methods, as well as some of the newest, more sophisticated methods.

1. Manipulation of environmental conditions - This might include increasing or decreasing the temperature or humidity beyond the pest's tolerance. Force drying of grain in storage, for instance, will greatly reduce the chance of stored grain pest buildup.

2. Capitalizing upon the pest's behavior - Many pests are attracted to light or various types of chemical attractants. Incorporated in a trapping system, these devices can become effective control agents.

3. Physical barriers - such as adhesive material, screens, shelters, electric or electronic devices can be employed to exclude pests. Coating the trunks of fruit trees with a sticky material like Tack Trap* can prevent the movement of many pests up or down the trunk.

4. Handpicking, jarring, shaking or mechanically collecting pests from the plant may be useful in some crop situations. The use of horse or tractor driven "hopper dozers" was a popular method of grasshopper reduction before the widespread use of aerially applied insecticides.

5. Use of weedfree seed will retard the development of undesirable plant species in crop areas. Weed control, in general, is an effective method of insect buildup prevention. Insects will often buildup and spread from weed populations in and around fields.

### Cultural Methods

1. Good sanitation practices around field and farm can help reduce pest buildup. Insects often seek refuge

in crop residue left after harvest. Thorough post-harvest cultivation or burning of refuse can effectively reduce many pest problems. Stored grain pests rapidly build up in piles of spilled grain and feeds around elevators and farm buildings.

2. Rotation of crops and adjustment of planting dates will often be effective in disrupting the relationship between crops and pests. Crop rotation is an effective method of reducing pests with limited means of dispersal. Corn rootworms can be effectively controlled by rotating corn with grain or some other non-host crop.

3. The application of fertilizers and the implementation of proper water management systems will produce stronger, healthier crops which in turn will be more resistant to attack by insects or disease.

4. The use of trap or buffer crops is effective in confining principal insect pests and certain plant nematodes to a small discrete area lending the pest population to more effective treatment with pesticides.

5. Regulation of crop composition by intermixing crop types will often retard or restrict the spread of insects or disease. Single crop or monoculture situations are extremely susceptible to destruction by insect pests and disease.

6. Proper selection of a growing site will help to limit pest outbreaks from the outset. The site should be selected to provide optimum growing conditions for the crop while avoiding obvious breeding areas for insects and disease.

7. The use of resistant or tolerant plant varieties is also advisable. Hessian fly resistant wheat, for example, has resulted in a savings to wheat producers in the millions of dollars.

## Biological Methods

It has been realized for some time that insect pests are adversely affected by their natural enemies. Parasites, predators, pathogens, adverse environmental factors, and population pressures act to hold most pest populations at sub-economic levels. Pests introduced to this country are usually not accompanied by their natural enemy complex, and once established, become very difficult to control.

Biological control, simply defined, is the deliberate use of natural enemies for the control of pest species. Biological control may involve:

1. Introduction of exotic parasites and predators involving isolation and identification of their natural enemies in foreign countries.

2. Conservation of natural enemies - protecting those natural enemies already present in the pest's environment or modifying the pest's environment to allow for an increase of natural enemies.

3. Augmentation of parasites and predators - involving the mass rearing and periodic release of natural enemies already present in the pest's environment and proven to be effective control agents.

Biological control systems have three basic advantages over other forms of control.

1. Permanence - Once established, a biological control program is, for the most part, permanent. The system is self-perpetuating providing that natural enemies are able to become firmly established in the environment of the pest. Natural enemies are capable of continually adjusting to changes in pest population size.

2. Safety - Biological control programs have no harmful side effects, such as toxicity or environmental pollution and can be handled without hazard.

3. Economic - Because biological control systems are self-perpetuating, they are far more economical, once established, than are continuous applications of pesticides.

Among the natural enemies of insects which may be employed in biological control systems are:

1. Predaceous and parasitic arthopods

2. Predatory vertebrates

3. Nematode parasites

4. Protozoan diseases

5. Parasitic fungi

6. Bacterial diseases

7. Virus diseases

Examples of Biological Control:

1. The introduction of the Australian lady beetle or Vedalia into California for control of the cottony cushion scale.

2. Introduction of hymenopteren parasites for control of the Citrophilus mealybug.

3. Parasitization of the alfalfa weevil by the wasp, Bathyplectes curculionis.

4. The utilization of predaceous mite species to control troublesome mites in apple and cherry orchards.

5. The use of a bacterial pathogen, Bacillus thuringiensis, for control of several species of crop damaging caterpillars.

## Autocidal Control

This method involves the genetic or mechanical (by radiation) manipulation of a pest population. The sterile male technique involving the mass sterilization of thousands of laboratory reared males of a pest species and their subsequent introduction into the natural population has been used successfully. This method, however, has limited application because of its cost. Chemically altering the genetic composition of a species is receiving much research attention. Field testing of this method is still at the trail stage.

## Insect Growth Regulators

Like plants, insect growth and development are regulated by hormones. Molting and development from one growth stage to another can be altered by regulation of the amount of the respective hormone given an insect. The application of juvenile hormone to a pest population is receiving considerable research at this time.

## Chemical Control

Insecticides are an established means of insect control. Their use can often provide a rapid, efficient, economical, and dependable means of pest control. Used properly, insecticides are an ecologically sound tool invaluable to a pest management program.

Insecticides do have limitations. Their direct and indirect adverse effects to non-target organisms and the environment, in total, is probably their principal disadvantage. Insecticides characteristically, select resistant traits in a pest population.

The development of resistance to some pesticides by insect pests has been one unfortunate result of "cure all" applications of pesticides. Resistance in this context is an example of evolution in action. All populations have the ability to develop resistance to poisons, diseases or other adverse effects. Insect pests are no different. Resistance is a highly selective process that separates out those individuals in every pest population possessing the ability to detoxify a chemical and render it harmless or to escape its effects through a behavioral change. Economics of pesticide application have contributed to the development of insect resistance to pesticides by dictating that application rates be sufficient to kill almost, but not all, of a pest population. Those individuals which survive pesticide treatment are consequently the most "resistant" forms. Their resistant qualities are then passed on to future generations resulting eventually in an entire population resistant to a particular pesticide or group of pesticides. For instance, application of DDT to control houseflies has resulted in the unnatural selection of housefly strains which require 10,000 times the dosage of DDT required to kill their predecessors. This scale of application is of course uneconomical, impractical and hazardous.

Two approaches may be taken to reduce the major disadvantages of present day insecticides.

Physiological selectivity - By developing insecticides with a narrow range of biological activity, the effects on non-target species can be appreciably reduced. These products are in sharp contrast to the present arsenal of broad-spectrum products.

Ecological selectivity - Altering the use patterns of many presently available insecticides can greatly reduce their adverse environmental effects. This approach is much less expensive and time consuming than the development of physiologically selective compounds. Some areas that can be altered to enhance insecticidal ecological selectivity are:

1. Timing of application - The proper timing of insecticide treatments will result in more effective control of the pest while using less insecticide and causing the least adverse effects on beneficial species. Timing involves:

    a. Treatments only when pest levels warrant

    b. Making the treatment to the most susceptible life stage of the pest.

2. Placement of the insecticide - More effective delivery of the insecticide to the target will reduce the amount of chemical needed for control and reduce the effect of the treatment on non-target species.

Seed treatment of corn, for example, with a suitable insecticide may be as effective at controlling wireworms, corn rootworm and other seedling pests than side banding or broadcast application. Seed treatment requires much less chemical and only affects those pests coming in contact with the seed.

3. Application equipment - Utilizing the right equipment, correctly calibrated, will ensure that more chemical reaches the target area. Improved equipment design can be a major factor in reducing the majority of the adverse effects of insecticidal treatments.

4. Insecticide formulation - The effectiveness of an insecticide can vary with the manner in which it is formulated. Different formulations may be more effective in certain treatment situations. Baits, low volume, and ultra low volume formulations have a potential for increasing control effectiveness while reducing adverse environmental effects.

## Integrated Pest Management

Todays concept of integrated pest management (IPM) began approximately 25 years ago, although some of the procedures and philosophies have been practiced for hundreds of years. IPM is an ecological approach to pest control, a realization that all pest populations are affected by the interactions of their environment. IPM is based on the premise that it is economically unnecessary to rid a crop completely of a particular pest. Most crops can tolerate some level of pest activity without a significant reduction in yield or quality.

IPM strives to protect the natural enemies of the pest complex active in a particular crop. The natural enemy complex is one of the most significant of the population limiting factors in a pest's environment and one of the most easily altered by man's manipulation of the crops.

Since the natural enemies require pests for their survival, sub-economic pest levels are encouraged. Natural enemies may be protected in hedge rows, strip crops, border plantings, cover crops, or other areas adjacent to the field. Should a chemical treatment be necessary, selection of a chemical that will only mildly affect the natural enemies while still reducing the pest population is preferred.

Mechanically speaking, IPM 1) assesses the pest population and crop conditions to determine if a need for treatment exists and, 2) selects the best combination of available control "tools" for the specific treatment need. Field application of IPM principles relies heavily upon a conscientious field monitoring program. Weekly or twice weekly scouting at several field locations by trained personnel provides pest and crop information vital to the detection of pest buildup. Information from several surveys is compared to determine the need for treatment.

CHAPTER V

# CHEMICAL CONTROL METHODS

## Introduction

The application of chemical insecticides remains one of the most effective and economical insect control strategies. While cultural, biological and integrated methods will increasingly provide effective alternatives, insecticides will continue as the basis for most pest management programs. It is important that the applicator and dealer alike have a strong understanding of the basic classification and characteristics of the insecticides they sell and apply.

## Insecticide Classification

Insecticides are just one of a large group of plant and animal control chemicals called pesticides. Insecticides, as the name implies, are chemicals especially developed to control insects.

Insecticides are generally classified by their chemical structure. There are two large groups of insecticides: 1) inorganic, and 2) organic compounds. Each of these groups is further broken down.

### Inorganic Compounds

Derived from basic chemical elements.

Arsenicals - containing some form of arsenic; active as a stomach poison.
Examples: lead arsenate, calcium arsenate

Fluorine Compounds - developed as more effective stomach poisons. Most of these compounds are no longer registered or seldom used.
Example: sodium flusoilicate

Sulfur Compounds - effective against mites and many sucking insects as a contact poison.
Examples: Kolofog, Sulfur

### Organic Compounds

This large chemical group consists of products with a structure based on the element carbon.

#### Natural Organic

Originating from plants or animals.

Botanicals - derived from plants; may act as a contact or stomach poison.

Examples: rotenone, nicotine, ryania, pyrethrum

Synthetic Organic

This group includes the most widely used chemical insecticides. They act primarily as contact poisons affecting the central nervous system of the pest.

Organochlorines - so named because of the presence of the element chlorine in their structure. Organochlorines generally exhibit long residual activity, a broad range of toxicity, and the tendency to accumulate in soil, water, plant and animal tissues. Many of the products in this group are no longer registered for use. Examples: DDT, Endrin, Chlordane, Toxaphene

Organophosphates - characterized by containing phosphorus in their chemical structure. These compounds have a shorter residual life than organochlorines, are generally more acutely toxic to man, and are rapidly degraded by sunlight, heat and water. Examples: Malathion, Parathion, Diazinon

Dinitrophenols - effective as contact poisons for mites, aphids, scales; commonly applied as a dormant spray.
Examples: Elgetol, DNOC

Carbamates - similar to the organophosphates. The carbamates as a group are rapidly degraded in the environment. Several of these products are extremely toxic to man, while others show a low mammalian toxicity.
Examples: Sevin, Baygon, Temik

Oils - hydrocarbon compounds used as contact insecticides; particularly effective against the egg stages of various insects and mites.
Examples: Dormant oils, Superior (Supreme) oils

Specialized Insecticides

In addition to these insecticide groups based on chemical structure, several other specialized categories can be described.

Compounds in this group are defined by their action or specialized make-up rather than by chemical structure alone.

Biologicals - specially formulated compounds of fungal, bacterial or viral organisms which act specifically on certain species or groups of insects. They may gain entry into the insect by ingestion or penetration of the body wall. Their highly specific nature and environmental safety make them very attractive.
Examples: Bacillus thuringiensis (Dipel, B.T.),
Beauveria bassiana, polyhedrosis virus

Attractants - formulations used to attract insects to a favorable location for control. This group also includes highly specialized attractants called pheromones. These compounds are synthetic mixtures of chemicals released by the female of the species to attract the male. Pheromones are very useful in monitoring certain pest population levels.
Examples: Disparlure, Codlelure

Repellents - used to repel insects from man and domestic animals.
Examples: Diethyl toluamide, Dimethyl phalate, Dibutyl phalate

Systemics - a specialized group of insecticides that are absorbed into and circulated throughout the host; particularly useful in the control of sucking insects.
Examples: Metasystox, Disyston, Thimet

Fumigants - these insecticides occur in liquid, gaseous, or solid form. Their active state is a gas. Fumigants are used to control insects in confined spaces, such as grain elevators, box cars, etc. Fumigants are extremely hazardous to the applicator and should be handled only by trained personnel. For a more complete discussion of fumigants, refer to Montana Department of Agriculture Training Manual for Fumigation.

## Factors Affecting Insecticide Application

Insecticides may be used to 1) prevent, or 2) correct an insect buildup. For most agricultural situations, preventative treatments made prior to any detection of a pest are not recommended. Because of the highly dynamic nature of insect populations, it is usually impossible to predict from one year to the next which insect pest, if any, will attack a particular crop.

A watchful eye can often provide the best warning of impending problems. Application of chemical insecticides on an "as needed" basis will reduce the cost of treatment, increase their effectiveness, and minimize the adverse environmental impact of the treatment.

Four principal factors will ultimately determine the overall effectiveness of insecticide applications.

1. Selection of the proper insecticide begins with correct identification of the pest. Chapters 1, 2, and 7 provide an account of pests you may encounter. If you are unfamiliar with the insect, have it identified by a qualified entomologist or pest control consultant.

2. Timing the insecticide application to coincide with the most vulnerable stage of the insect pest is very important. Some applications are aimed at the egg or larval stage while others are intended to control the adults. An understanding of the life cycle of the insect is essential in determining the best time to apply the insecticide. Consult a good insect pest field guide, the local extension agent or pest control specialist.

3. Frequency of application - Preventive insecticide applications may require the use of a product with long residual toxicity. Due to the variety of situations requiring pest control operations (fields, forests, storage areas, etc.), restrictions on residual insecticides may be quite stringent. Recurring pest problems may require more frequent applications of insecticides. Frequency of application is dependent on the treatment area, the insecticide employed, the recurrence of infestations, and the success obtained with the application.

4. Quality of application - Quite often the failure of a product to control a pest is related to the manner in which the chemical was applied. For most pest situations, it is critical to get the chemical to the plant region occupied by the pest. Selection of the proper equipment for given treatment, proper calibration and maintenance of the equipment and proper operation of the equipment by trained personnel will greatly increase the effectiveness of the treatment.

# CHAPTER VI

# PESTICIDES AND POLLINATING INSECTS

## Introduction

Pollination is essential and basic to the reproduction of most plants. Only through pollination can fertilization of the plant occur leading to flower, fruit, and seed production. Wind and insects are the chief agents of pollination. Insects are probably the most important pollinating agents of agricultural crops. Included in this group are some fifty species of crop plants in this country; among them apple, pear, sweet cherry, cucumber, cabbage, alfalfa, and many clovers.

Pollinating insects include thousands of species distributed among the bees, wasps, butterflies, moths, flies, gnats, and beetles. Bees and other insects visit flowers to collect pollen or nectar as food for themselves or their young. Transportation of the sticky pollen grains from one flower to another is strictly an incidental activity.

The first settlers to this country depended upon native insects - wild bees, wasps and beetles - for pollination of their crops and flowers. Although honeybees were colonized in North America before 1638, they were probably more important as honey producers. Native insects were effective pollinators as long as crops were planted in small fields surrounded by wild land. With expanding agriculture, the wild pollinators were spread widely apart and their effectiveness greatly reduced.

Honeybees have largely assumed the role of pollinators of agricultural and fruit crops throughout the world. Breeding and rearing methods have greatly increased the versatility and effectiveness of domestic beekeeping. The beekeeper of today cannot only profit from honey produced by his bees but also from the pollination they accomplish while gathering the honey constituents. An estimated 80 percent or more of our commercial crops are pollinated by honeybees.

Nearly all chemical pesticides are toxic to members of the insect order Hymenoptera (bees and wasps), by far the most important group of pollinating insects. Disregard for these beneficial insect species may result ultimately in considerable economic loss. A decrease in harvestable product through lack of adequate pollination and a decrease in production of honey may occur. In addition, direct losses to the beekeeper resulting from colony destruction must be considered. Extensive use of insecticides has driven beekeepers out of many localities, creating a serious impact on production of legumes grown for seed, cotton, apples, and other fruits dependent upon bee pollination.

The conflict between insecticide application and the beekeeping industry can be traced back to the 1870's when piles of dead bees appeared around hives after application of Paris green for control of codling moth on apples and pears. In 1920, the application of calcium arsenate dust by aircraft for control of cotton boll weevil began. Corresponding losses of honeybees were recorded. It was not uncommon for beekeepers in the cotton regions to lose 500 colonies in a season. Many beekeepers were slowly driven out of business. Similar results were reported wherever arsenicals were applied.

Synthetic insecticides presented new problems for beekeepers. These compounds differ slightly in their effects on bees. The arsenicals kill large numbers of bees near the hive entrance while many of the synthetic insecticides, like chlordane, cause bees to die in the field away from the hive. These latter insecticides kill only the field force of bees. The affected colony may recover its strength in time. However, repeated exposure to these compounds will weaken the colony strength to such an extent that the honey crop fails, resulting in ultimate loss of the entire colony.

Herbicides and fungicides do not greatly affect pollinating insects directly, however, they do affect them indirectly. The action of added carriers or surfactants may either cause harm to the insects themselves or render the food source undesirable. Many wild pollinators rely heavily upon weeds such as sweetclover, dandelion, knapweed, and mustard as a source of food. Roadside spraying of herbicides may seriously reduce food supplies in some areas resulting in decline of pollinator numbers.

Pollinators come in contact with pesticides in numerous ways:

1. By direct contact with insecticidal applications made to fields in the daylight hours while the fields are in bloom.

2. By insecticide applications made directly over beehives. Such applications are especially devastating in daylight hours because bees travelling to the hives may fly through the spray to get to the hives.

3. By drifting of toxic spray applied to adjoining crops onto crops which pollinators are working or into the area of beehives.

4. By residual deposits of insecticides on the crops which may kill the insects two or three days or longer after the crops have been sprayed.

5. By contact with insecticide poisoned pollen and nectar which the insects take back to their nest or hive and

feed to the young or consume themselves. Bees will collect almost any kind of dust, including road dust or insecticide dust if pollen is not available.

6. By poisoning of water supplies. Bees need water for their hives and other pollinators need water to carry on normal functions.

## Protection of Pollinators

A pamphlet written by Dr. Carl A. Johansen of Washington State University entitled "How to Reduce Poisoning of Bees from Pesticides" (publication E.M. 3473) gives some excellent suggestions as to what interested persons can do to reduce pollinator poisoning. The following seven suggestions are reprinted from that pamphlet:

What The Pesticide Applicator Can Do

1. Do not apply insecticides that are toxic to bees on crops in bloom, including cover crops in orchards and adjacent crops or interplants. With aerial applications, do not turn the aircraft or transport back and forth across blossoming fields. Ground application is generally less hazardous than aerial application because there is less drift of the pesticides and smaller acreages are treated at one time.

2. Apply certain chemicals only in late evening, night, or early morning while bees are not actively foraging (generally between 6 p.m. and 7 a.m.). Evening applications are generally less hazardous to bees than early morning applications. When high temperatures cause bees to start foraging earlier than usual e.g. 5:30 a.m., application time should be shifted accordingly. Likewise for evening applications, warm weather sometimes extends to 8 p.m.

3. Do not dump unused dusts or sprays where they might become a bee poisoning hazard. Sometimes bees collect any type of fine dust materials when pollen is not readily available. Under such conditions, they may actually carry pesticide dusts back to the colony.

4. Use insecticides that are relatively nonhazardous to bees whenever such choices are consistent with other pest control considerations. Tables 4 and 5 group insecticides by relative toxicities, and can be used to assist in such choices. Baygon, Baytex, Malation ULV, and Dursban are listed in the most toxic category but note the notation at the bottom of the table.

5. Choose the less hazardous insecticide formulations. Tests have consistently indicated that dusts are more hazardous than sprays of the same insecticide. Emulsifiable (liquid) formulations usually have a shorter residual toxicity to bees than do wettable powders. Granular formulations are low in hazard to bees.

6. Contact the beekeeper and ask him to remove his colonies from the area (or keep the bees confined during the application period) before applying hazardous pesticides when such measures are feasible and of value.

7. When roadside and other weed control operations involve 2,4-D and similar compounds on blooming plants, select the formulations or derivations known to be less harmful to bees. Tests have shown that at maximum dosage, alkanolamine salts and isopropyl esters are more toxic than other forms. Oily formulations seem to be more hazardous to bees. Spraying in late afternoon or evening will also lessen the hazard, since bees will not visit the blooms after they become curled. The only highly toxic herbicides are arsenicals, dinoseb, and endothal.

## The Beekeeping and Pesticide Industries

The beekeeping industry and the pesticides industry need not represent two areas of conflicting interest. In fact, both beekeeping and pesticide application complement each other. By applying pesticides in a safe and proper manner, the agriculturalist will produce healthier plants. Healthier plants produce more nectar which in turn allows beekeepers to harvest larger crops of honey. Beekeepers provide an esential service to the agriculturalist by supplying the necessary means required for pollination of his crops.

No insecticide is so species specific that non-target insects are not endangered. Application of pesticides will always result in the killing of beneficial pollinators, both domestic and wild. There is little way in which this can be avoided. However, this unfortunate result of pesticide application can be greatly minimized.

Refer to Table 4. "Toxicity of Insecticides to Honey Bees" and Table 5. "Toxicity of Insecticides to Alfalfa Leafcutting Bees" for specific information on types of pesticides and when they may or may not be applied to crops in order to protect bees.

Table 4. Toxicity of Insecticides to Honey Bees

Do NOT apply on blooming crops or weeds:

Ambush (permethrin)
Azodrin (monocrotophos)*
Baygon (propoxur)
Baytex (fenthion)
Bidrin (dicrotophos)
Bomyl
Cidial (phenthoate)
Cygon (dimethoate)
Dasanit (fensulfothion)
De-Fend (dimethoate)
diazinon
Bibrom D (naled)
dinoseb (DNOSBP)
EPN
Folimat
Furadan F (carbofuran)
Guthion (azinphosmethyl)
heptachlor
Imidan (phosmet)
Lannate D (methomyl)
lindane
Lorsban (chlorpyrifos)
malathion D
malathion ULV
Mesurol
methyl parathion
Monitor (methamidophos)
Nordin D (methomyl)
parathion
Penncap-M (methyl parathion)*
Phosdrin (mevinphos)
phosphamidon
Pounce (permethrin)
Pydrin ( over 0.1 lb/acre)
Rebelate (dimethoate)
Sevin (carbaryl)
Sevin ULV (more that 0.5/acre)
Sumithion (fenitrothion)
Supracide (methidathion)
Temik G (aldicarb) (applied at least 4 weeks before bloom)
Vapona (dichlorvos)
Zectran (mexacarbate)

* Can cause serious problems if allowed to drift onto vegetable or legume seed crops.

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Apply ONLY during late evening. (See caution at end of table)

Dibrom WP (naled)
malathion EC
Orthene (acephate)
Pydrin (0.1 lb/acre or less)
Thimet EC (phorate)

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Apply ONLY during late evening, night, or early morning. (See caution at end of table)

Aspon (propyl thiopyrophosphate)
Baygon MA (propoxur)*
Baytex MA (fenthion)*
Carzol (formetanate)
Delnav (dioxathion)
Dibrom EC (naled)
Di-Syston EC (disulfoton)
Dursban MA (chlorpyrifos)*
Dyfonate (fonofos)
Dylox (trichlorfon)
endrin
ethion
Gardona (stirofos)
heptachlor G
Kroneton
Lannate LS (methomyl)
malathion MA*
Malonoben
menazon
Matasystox-R (oxydemetonmethyl)
methoxychlor
Mobilawn (dichlorfenthion)
nemacide (dichlorfenthion)
Morocide (binapacryl)
Nodrin LS (methomul)
oil sprays (superior type)
Perthane
Pirimor(pirimicarb)

## Table 5. Toxicity of Insecticides To Alfalfa Leafcutting Bees

Do NOT apply on blooming crops or weeds.

Ambush (permethrin)
Azodrin (monocrotophos)
Baygon (propoxur)
Bidrin (dicrotophos)
Carzon (formetanate) (1 lb/acre or more)
Cidial (phenthoate)
Cygon (dimethoate)
De-Fend (dimethoate)
Di-Syston (disulfoton)
endrin
ethion
Furadan F (carbofuran)
Gardona D (stirofos)
Guthion (azinphosmethyl)
Imidan (phosmet)
Lannate (methomyl) (1/2 lb/acre or more)
malthion
Malonoben (1 lb/acre or more)
methoxychlor D
methyl parathion
Monitoe (methamidophos)
Nudrin (methomyl) (1/2 lb/acre or more)
Orthene (acephate)
parathion
Phosdrin (mevinphos)
phosphamidon
Pounce (permethrin)
Primicid (pirimisphos-ethyl)
Pydrin
Rebelate (dimethoate)
Sevin (carbaryl)
Supracide (methidathion)
Temik G (aldicarb) (applied at least 4 weeks before bloom)
TEPP
Thidan (endosulfan)
toxaphene
Trithion (carbophenothion)

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Apply ONLY during late evening. (See caution at end of table)

Actellic (pirimiphos-methyl)
Dibrom EC (naled)
Gardena EC stirofos)
Kelthane + Dylox + Systox
Lannate (methomyl) (1/4 lb/acre or less)
Malonoben (1/2 lb/acre or less)
methoxychlor WP
Nudrin (methomyl) (1/4 lb/acre or less)
Omite + Dylox + Systox

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Apply ONLY during late evening, night, or early morning.

Carzol (formetanate) (1/2 lb/acre or less)
Delnav (dioxathion)
Dylox (trichlorfon)
Metasystox R (oxydemetonmethyl)
methoxychlor EC
Pirimor (pirimicarb)
Proxol (trichlorfon)
Systox (demeton)
Tedion (tetradifon)
Thimet G (phorate)
Vydate (oxamyl)
Zolone (phosalone)

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Can be applied at any time with reasonable safety to bees.

Baygon G (propoxur)
Comite (propargite)
Di-Syston G (disulfoton)
Furadan 3 (carbofuran)
Kelthane (dicofol)
menazon
Omite (propargite)

Table 5 Continued

Apply ONLY during late evening, night, or early morning. (Cont'd)

Proxol (trichlorfon)
Rhothane (TDE)
Sevin ULV (0.5 lb/acre or less)
Systox (demeton)
TEPP
Thanite (isobornyl thiocyanate)
Thimet G (phorate)
Thiodan (endosulfan)
Torak (dialifor)
toxaphene
Trithion (carbophenothion)
Vapona MA (dichlorvos)*
Vydate (oxamyl)
Zolone (phosalone)

*MA - concentrate applications at mosquito abatement rates

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Can be applied at any time with reasonable safety to bees.

Acarol (bromopropylate)
allethrin
BAAM
Baygon G (propoxur)
chlorobenzilate
chloropropylate
Comite (propargite)
cryolite
Dasanit G (fensulfothion)
Dimilin (diflubenzuron)
Di-Syston G (disulfoton)
Furadan G (carbofuran)
Karathane (dinocap)
Kelthane (dicofol)
Lethane 384 (butoxy thiocyano-ethyl ether)
lime-sulfur
malathion G
Micasin (chlorfensulphide)
Milbex (chlorfensulphide)
mirex
Moreston (oxythioquinox)
nicotine sulfate
Ovex (chlorfenson)
Omite (propargite)
Pentac
Plictran (cyhexatin)
pyrethrum
rotenone
ryania
schradan
Sevin G (carbaryl)
sodium fluosilicate baits
sulfur
Tedion (tetradifon)
Vendex (fenbutatin-oxide)

CAUTION: Timing of insecticide applications in respect to bee poisoning hazard can be drastically modified by abnormal weather conditions. If temperatures are unusually low following treatment, residues on the crop may remain toxic to bees up to 20 times as long as during reasonably warm weather. Conversely, if abnormally high temperatures occur during late evening or early morning, bees may actively forage on the treated crop during these times.

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## Reducing Pesticide Damage to Honeybees, Alfalfa Leafcutting Bees and Other Pollinators

There are three basic ways to reduce pesticide damage to pollinators - the use of consideration, common sense and cooperation. Consideration involves realizing that the beekeeping industry is an important part of agriculture because of the vital pollination service it provides and that any pesticide damages to bee colonies may have a severe economic affect upon individual beekeepers who rely upon beekeeping for their livelihood. Realizing these two points, efforts should be taken to prevent any pesticide damages to honeybees and other pollinating insects.

Common sense involves selecting and applying damage preventative methods (such as Dr. Johansen's methods listed previously) to each pesticide application situation. For example, if two different insecticides are both effective in controlling a pest insect, select the one which is least toxic to bees.

Cooperation between pesticide applicator and beekeeper is perhaps the most important point in reducing pesticide damage to bees. Discussion of tentative plans for pesticide application between the applicator and the beekeeper will prevent most pesticide damages to honeybees. If a pesticide applicator contacts those beekeepers in advance who may be affected by a certain application, the beekeeper can remove his bees from the area and prevent serious damage from occurring.

## CHAPTER VII

## SELECTED CROP PESTS AND THEIR CONTROL

### Introduction

Limited space does not permit an extensive listing of all agricultural insect pests. Chapter VII attempts to describe the major pest species attacking the principal agricultural crops in Montana. Recommendations for controlling these pests are current as of February 1981. For verification of the registration status of any listed chemical, please contact the Montana Department of Agriculture, Environmental Management Division. Listing of chemicals in this manual by no means implies a preference for one product over another. Omission of a registered product was inadvertent. Please consult product labels for specific use, mixing information , and interval to harvest instructions.

### ALFALFA HAY

#### Alfalfa Caterpillar
(*Colias eurytheme*)

Caterpillars are green with a fine white stripe on each side of the body. Infestations occur all through the summer. They are normally controlled by natural enemies but heavy infestations may require insecticide treatment. Adults are a yellow or white butterfly with black wing margins and a wing span of 2 inches.

ALFALFA CATERPILLAR

Control

Treatment when caterpillars are present with one of the following products: Dylox, methoxychlor, methomyl, Bacillus thuringiensis (BT, Thuricide, Dipel), Phosdrin.

ALFALFA LOOPER

Alfalfa Looper
(Autographa californica)

Caterpillar is green, the same shade as foliage, with dark brown head. Moves over the plant in a looping motion.

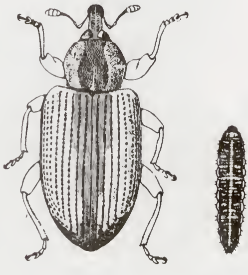
Moth has dark mottled gray markings on forewings and a wingspan of 1½ inches. Moths appear early; several generations each year.

Control

Dylox, malathion, Bacillus thuringiensis (B.T., Dipel, Thuricide), methomyl

Alfalfa Weevil
(Hypera postica)

This insect is distributed statewide. Alfalfa weevil larvae do the greatest damage to the first crop of alfalfa by feeding within the plant tips, on the upper leaves as they open, and later on the lower foliage. Damaged leaves dry rapidly and infested fields have a grayish or whitish cast. The second crop may or may not be affected economically by this weevil.



Adult Larva

ALFALFA WEEVIL

Alfalfa weevil undergo complete metamorphosis (egg, larva, pupa, adult). The weevil (eastern and western varieties) overwinters as an adult, emerging in the spring and depositing eggs in the stems of new plants. The eastern variety may also lay its eggs in the fall. The eggs hatch in 1-2 weeks, depending on the temperature. The larvae feed on alfalfa 3-4 weeks prior to pupation. In Montana, adults normally appear in August. The young adults leave the field soon after emergence and remain inactive until they return to mate in the fall. Adults of the eastern variety may lay eggs for a short time in the fall before cold weather sets in. These eggs are placed in old, hollow alfalfa stems or weeds. The western variety overwinters as an adult, waiting for spring to begin egg laying.

Control

Certain practices can be useful in reducing damage by alfalfa weevil. If populations reach 20 per sweep of a 15" sweep net at several points in the field, early cutting of the crop may eliminate the need for chemical treatment. Occasionally, enough larvae may survive the first cutting to hold back the growth of the second crop. Should this occur, chemical treatment may be warranted. Treatment for alfalfa weevil should be applied only when necessary and not as a preventative treatment.

The following chemicals are registered for control of alfalfa weevil larvae: Diazinon, Furadan, Guthion, Imidan, malathion, methomyl, methoxychlor, methyl parathion, Supracide, Phosdrin.

Aphids

Pea Aphid (Acyrthosiphon pisum)
Spotted alfalfa aphid (Therioaphis maculata)

APHID

Aphids may reach damaging proportions in alfalfa. In Montana, the most prevalent aphid in alfalfa is the pea aphid. Adults and young (nymphs) feed by sucking juice from leaves, stems and flower buds. Young plant growth is preferred. Feeding causes alfalfa to turn yellow and wilt. Heavy infestations result in "top kill" and may cause failure of first crop and severe reduction in the yield of succeeding crops. Only severe infestations require chemical treatment.

The spotted alfalfa aphid is not well established in Montana. Its life history, damage to alfalfa and control are similar to the pea aphid.

Aphids (cont.)

Control

Alfalfa plants can generally tolerate relatively high populations of aphids (especially pea aphid) with little reduction in quality or yield. The pea aphid is considered injurious when levels exceed 100 per sweep of a 15" sweep net and the plants are less than a foot high. If the crop is growing well and not under stress and aphid predators and parasites can be found in the field 300 or more aphids can be tolerated without chemical treatment.

Chemicals registered for aphid control include: malathion, methyl parathion, diazinon, Di-Syston, dimethoate, Trithion, Supracide, Systox, Thimet, methomyl, phosdrin, Penncap M.

Armyworms

Includes Western yellow striped (*Spodoptera praefica*), Bertha (*Mamestra configurata*), and Beet armyworm (*Spodoptera exigua*)

Caterpillars are 1½-2" in length when mature. They are velvety black in color with 2 prominent and several fine bright yellow stripes on the sides. They differ from most cutworms in that they generally feed during the day and rest at night.

ARMYWORM

Control

Treat when damage appears and caterpillars are small but evident.

Registered chemicals include: Dylox, malathion, methyl parathion, methomyl, Sevin.

Army Cutworm
(*Euxoa auxiliaris*)

The larvae of this nightfeeding insect attacks alfalfa in the early spring, March-May, destroying small plants and preventing the growth of early foliage. Bare

CUTWORM

spots begin to develop in the field, grow in size, and the entire crop may be destroyed. Insecticides may not give satisfactory control because of the cold weather at the time of peak infestation.

Control

Examine around base of plants in late afternoon and evening for evidence of army cutworm. Irrigation of the field prior to treatment may improve control.

Chemicals registered for army cutworm include Dylox (liquid or bait), Sevin (liquid or bait), methoxychlor.

Spittle Bugs

Nymphs of the meadow spittle bug (Philaenus spumarius) can be a serious pest of alfalfa when populations are large. Yield of hay may be reduced 25-50 percent by heavy infestations of this pest. Nearly all the feeding damage is done by the young nymphs which stunt plant growth by sucking out plant juices. Heavily infested plants wilt during hot weather.

SPITTLE BUG

The first nymphs appear in April, May or early June, hatching from eggs laid the previous August or September in grain stubble or old plant stems. By forcing air through a liquid which they secrete, the young nymphs envelop themselves in a frothy mass of spittle. When adults appear in the field, it is too late for insecticide control but their presence indicates there will be nymphs present the following year.

Spittle bugs are quite mobile and are not likely to remain in one part of the field for long. Even when numerous, adults do not injure plants seriously.

Treatment of heavy spittle bug nymph infestations is profitable, however, it is best to determine if the population is large enough to require treatment. Presence of many spittle masses does not necessarily indicate the damage potential is great.

Control

Treatment of heavy spittle bug infestations only when the populations are large is the best control. Presence of spittle masses does not necessarily indicate a need for treatment.

Registered chemicals include methoxychlor, Guthion, Trithion.

GRASSHOPPER

Grasshoppers
(*Melanoplus spp*)

Both young and adults of several species feed on alfalfa. Nymphs emerge from egg pods in early spring and begin to feed. Infestations often develop along roadsides and field margins, gradually moving into the field.

Control

In areas experiencing perennial grasshopper problems, control efforts should be directed at the grasshopper nymphs. Treatment of field margins when populations warrant may eliminate the need for treatment of the entire field.

Chemicals registered for grasshopper control on alfalfa include malathion, diazinon, Sevin (liquid or bait), Phosdrin, Guthion, Dimethoate, Furadan, and Cygon

## AFALFA SEED

There is currently an Integrated Pest Management Program for alfalfa seed pests in Montana. The use of the program's techniques will provide the grower with invaluable information concerning the need to treat and time treatments for control of insect pests. Contact the Pest Management Specialist, Cooperative Extension Service, Montana State University, Bozeman, Montana for details.

### Alfalfa Looper
(*Autographa californica*)

See previous section for description of life cycle.

#### Control

When looper populations reach an economic level, treat with one of the following registered chemicals: Dylox, toxaphene, methomyl, *Bacillus thuringiensis* (BT, Dipel, Thuricide).

### Alfalfa Seed Chalcid
(*Bruchophagus roddi*)

Damage by the larvae of this tiny metallic wasp occurs during June, July and August. Larvae mine out alfalfa seed and pupate inside. Three or more generations per season. Adults overwinter in alfalfa straw or weeds.

ALFALFA SEED CHALCID

#### Control

Presently, there is no satisfactory chemical control of this pest. Cultural methods include burning threshings, removing volunteer alfalfa and clover from the area, and cutting the crop early. Disking to bury light seeds at least 1 inch in soil during the fall will reduce emergence.

### Alfalfa Weevil
(*Hypera postica*)

See previous section for description of life cycle.

Alfalfa Weevil (cont.)

Control

Larval Control - Pre-Bloom Application

Chemicals used for control include malathion, methoxychlor, diazinon, Supracide, Furdan, methomyl, Imidan, parathion. Treatment is recommended when populations reach 20 larvae per sweep or more. Preventative applications are not recommended for this pest.

Aphids

Description and treatment levels are the same as listed under alfalfa hay.

Control

Pre-bloom

Chemicals registered are Di-Syston (liquid or granular) Dimethoate, parathion, methyl parathion, and malathion.

Bloom or Pre-bloom

Chemicals include Systox, Metasystox R, and Thiodan.

Armyworms

Refer to previous section for description.

Control

Chemicals registered for control include Dylox, malathion, toxaphene, methomyl, and Dibrom.

Army Cutworm

Refer to previous section for description.

Control

Control chemicals include Dylox bait, toxaphene, methoxychlor, and Sevin bait.

Grasshoppers

Grasshopper feeding on the blossoms of alfalfa grown for seed can prevent seed formation. For futher description, refer to the previous section.

Control

Pre-bloom only

Chemicals include dimethoate, malathion, toxaphene, diazinon, Furadan and Cygon.

Lygus Bugs
(*Lygus* spp.)

Primarily a pest of alfalfa crops grown for seed, these Hemipterans can cause considerable damage to all alfalfa crops. Adults overwinter in plant debris and weeds, becoming active on the first warm days of spring. The adults mate soon after emerging and immediately begin laying eggs in plant tissues. Eggs hatch in 1-4 weeks, depending on the temperature and the young pass through 5 nymphal instars requiring about 3 weeks. Adult females begin egg laying in about 10 days. Three or four generations per season may occur depending on climatic conditions.

LYGUS BUG

Alfalfa buds turn white and die 2-5 days after lygus bugs feed on them. Large infestations of the insect may prevent blooming. Lygus bugs also destroy immature seeds causing them to shrivel and turn brown.

Control

Pre-bloom

Chemicals for control include Dimethoate, Furadan, Supracide, toxaphene, and Dibrom.

Bloom or Pre-bloom

Chemicals include Dylox and Metasystox R. Consult the Extension Pest Management Specialist for treatment threshold information.

THRIPS

Thrips
(*Frankliniella spp.*)

Several species of thrips attack alfalfa, destroying flower parts and rasping leaves and stems. Seed yields can be cut greatly when high populations develop. Predators and parasites frequently keep thrips numbers down.

Control

Chemical control is not recommended when directed solely at thrips. Nearly all treatments directed at other pests will also control thrips.

# CORN

## Aphids

Several species of aphids are found attacking corn. The corn leaf aphid is a widely distributed green aphid with a dark green head. It feeds in the heart leaves, young tassels, and heads of corn and sorghum.

### Control

Chemical control includes Di-Syston (liquid or granules), Thimet, Metasystox R, malathion, diazinon and Phosdrin.

APHID

## Armyworms
(several species)

Larvae are usually greenish with dark lateral bands edged with a narrow white band. They feed on corn leaves and stems. Mature caterpillars are 1½-2" in length.

### Control

Control methods include Dylox, Furadan,methomyl, and toxaphene.

ARMYWORM

## Corn Earworm
(*Heliothis zea*)

Corn earworm is one of the most destructive insects to corn grown in the United States. Adult moths fly at dusk and deposit their eggs on corn silk and other parts of the plant. Eggs hatch in a few days and the larvae feed (downward) through the silks into the ear tip where they feed on the kernels and foul them with excrement. Rarely do they bore through the cob or husks.

CORN EARWORM

Corn Earworm (Cont.)

Secondary loss from molds which follow the feeding of the worm is often extensive. After feeding for 3-4 weeks, the larvae leave the ear and pupate in the soil. They overwinter in the pupal stage. Usually two generations per year.

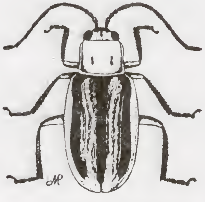
Control

Corn earworm is controlled by a variety of biological mortality agents. Some sweet corn varieties are ear-worm resistant. Fall or spring plowing reduces the number of moths that emerge from overwintering pupae.

Registered chemicals for earworm control include methomyl (Lannate and Nudrin) and Sevin.

Western Corn Rootworm (Diabrotica virgifera)

The adults are light greenish-yellow beetles with three longitudinal black stripes down the back. The larvae of this insect do the greatest damage.



CORN ROOTWORM

The eggs are deposited in the soil of corn fields during August and September. Each female lays large numbers of eggs at any depth up to six inches. Overwintering takes place in the egg stage. Larvae, hatching in the spring, attack seedling plants at the time the crop is beginning its early growth. Larval feeding on the roots makes the corn lodge and greatly weakens the surviving plants, causing them to goose-neck. Larval feeding also exposes root tissue to infection by disease organisms.

Later, the larvae enter the pupal stage and are transformed into adults. When the corn is in the silk stage, the adult beetles emerge and feed on the silks. Damaged silks destroy the ability of the plant to pollinate, thus no kernels develop on the cob. The northern corn rootworm is also found in Montana. Adults of this species are light green with no spots or stripes.

## Western Corn Rootworm (Cont.)

### Control

Practicing crop rotation is an effective means of controlling corn rootworm. Adults tend to lay eggs only in corn fields. Since the larve can only survive on corn roots, planting the field periodically to another crop will reduce corn rootworm populations.

Chemicals registered for rootworm control include Furadan (granules or spray), Thimet (granules or spray), fonofos (granules or spray), Dasanit (granules or spray), and Counter.

## Cutworm
(Several Species)

These caterpillars may be red, green, or black larvae usually up to 1½" in length. Cutworm larvae tunnel into the base of the plant, cut off seedlings, or feed on foliage. Most cutworms prefer to feed under low light conditions, consequently, it may be difficult to find the larvae during the day. Inspection around the base of plants on cloudy days or in the evening will be more rewarding.

### Control

Chemical control includes Sevin (spray or bait), Dylox (spray or bait).

## European Corn Borer
(*Ostrinia nubilalis*)

This insect is often a serious threat to corn crops. Larvae overwinter in corn stalks and other debris lying in the field. In the spring, emerging larvae soon enter the pupal stage. Adult moths emerge in late June and lay eggs on the underside of corn leaves. The moths are most active in the evening and are seldom seen during the day. The tallest corn plants are sought by the female for egg laying, thus becoming the most heavily infested.

EUROPEAN CORN BORER
LARVA

Eggs hatch in 6-12 days. Newly hatched larvae begin feeding on any part of the corn plant. Most damage results when feeding occurs in the early stages of corn development. Feeding results in damaged leaves, girdled sheaths, and tunneled stalks. Damage is later extended to the silks, tassle stalks and eventually the ear itself.

Since some 80 percent of corn grown in Montana is feed corn, second broods of the corn borer usually fail. Ensilage corn is cut with the larvae still feeding and most overwintering larvae are lost in the silage process. Some second brood larvae may complete their development on ear corn.

EUROPEAN
CORN BORER

Adult

The European corn borer has many natural enemies, both native and imported, which act to keep populations low in most areas. Hybrid corn varieties have been developed that are resistant to corn borer attack. Planting dates may be adjusted according to locale to avoid the greatest period of susceptibility to corn borer attack. Cultural methods include the plowing under of all post-harvest debris to control overwintering sites of borer larvae.

### Control

Insecticides may be applied but the timing is very critical, especially when treating the second brood. Be sure that insecticide application is economically justified. Control may be justified when 50-75 percent of the plants show feeding injury in the whorl stage. Treatment should be made after 7 days if feeding activity continues. Application for control of second brood is usually not required in Montana. If application is necessary, it should be made when the corn is in the green stage. The second brood larvae around the leaf sheath are vulnerable for 5-7 days before they enter the stalks. Two applications may be required.

Chemicals registered for control include Diazinon, Furadan, Lannate, Nudrin, Sevin, Parathion and Thimet.

Grasshoppers
(*Melanoplus* spp.)

Grasshoppers can damage corn in the nymphal and adult stages. Leaves, stalks and ears may be attacked.

Control

Treatment of young grasshoppers around headlands, roadsides and field margins will help prevent serious damage within the field.

When treatment is required, the following products are registered: Malathion, Sevin (liquid or bait), Diazinon, and Cygon.

Spider Mites
(*Tetranychus urticae* and others)

Spider mites are often most numerous in surface irrigated corn fields. Infestations may become damaging during the dry weeks of July and August. Insecticide applications for control of other pests, such as corn rootworm, may lead to a rapid buildup of spider mites. Spider mites usually begin feeding on the lower leaves and work upward on the plant, resulting in considerable leaf drying. If damage appears near harvest time, stepping up the cutting date is the best control. If damage appears early, chemical treatment may be necessary.

SPIDER MITE

Control

Chemical control includes Metasystox R, Di-Syston, Thimet, Trithion, and Comite.

Wireworms
(*Limonius* spp.)

These hard, smooth, yellowish worms are larvae of the common click beetle. They eat into the germinating seed or burrow into the underground part of the stem. Wireworms may persist in the soil for several years weakening corn plants, although their damage is not usually serious. Wireworms are usually not prevalent in continuous corn or other row crops.

WIREWORM

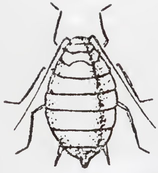
Control

Chemical seed treatment will reduce damage by wireworms. Chemicals registered for wireworm control include Diazinon, parathion, Dyfonate, Furadan, Dasanit, lindane, and Counter.

## POTATOES

### Aphids

Four species of aphids attack potatoes but the green peach aphid (Myzus persicae) probably does the most damage in Montana. Other species include the potato aphid (Macrosiphum euphorbiae), Foxglove (Acyrthosiphon solani), and Buckthorn (Aphis nasturtii). Like typical aphids, the green peach aphid feeds by inserting its needle-like mouthparts into potato plant tissue and sucking out the juices. Moderate aphid infestations cause crinkling or curling of younger leaves and wilting and yellowing of older leaves, sometimes resulting in death of the leaves.



APHID

Aphid honeydew (excreted plant sap) may coat leaves and entire plants and interfere with plant metabolism. Heavy aphid populations stunt the plants or kill them prematurely and thus reduce crop production. Aphids are very important transmitters of virus diseases, among them are potato leafroll, mosaic, calico, and others.

There are winged and wingless forms of the green peach aphid and several alternate hosts may be involved in the life cycle. Aphid populations can be reduced, when necessary, by the application of an insecticide.

#### Control

Aphids are more important as virus vectors on potatoes than as foliage pests. Chemical applications to seed potatoes are required at very low aphid population levels to prevent spread of serious viral diseases in the field.

Chemical registered for aphid control on potatoes include Temik, Thimet, Di-Syston (liquid or granular) Monitor, Thiodan, Phosdrin, Systox, Metasystox-R, Pirimor, and phosphamidon.

Armyworms, Cutworms, and Loopers
(Several Species)

Caterpillars may vary from reddish to black or green with light stripes along the sides. Cutworms are generally active early in the growing season while armyworms and loopers are mid-season pests. All three groups feed on foliage and stems. There may be one or two generations of armyworms and loopers per season. Mature larvae will measure 1½-2" in length. The adults are mostly night flying moths. In some seasons, chemical control will be necessary.

Control

Chemical control includes the use of Monitor, methomyl, Thiodan, Sevin, *Bacillus thuringiensis* (BT, Dipel, Thuricide).

Colorado Potato Beetle
(*Leptinotarsa decemlineata*)

This black and yellow beetle is one of the most widespread and destructive pests of potatoes in this country. This insect causes direct damage by defoliating plants and also helps to spread several potato diseases, including brown rot, bacterial wilt, spindle tuber, and ring rot.

The eggs are laid in clumps of 10-30 on potato leaves. The eggs hatch in 4-9 days and the tiny larvae immediately begin to feed. Larvae pass through four instars, becoming full grown in 2-3 weeks. They then enter the soil to pupate. The adults emerge in about 2 weeks and climb up the plants, feeding for a short time before laying their eggs. There may be 1-3 generations per year depending on climatic conditions.

1

COLORADO POTATO BEETLE

Colorado potato beetles have many natural enemies which act to keep populations low by preying on eggs, larvae, and adults.

Control

Chemicals employed to control this pest include Malathion, Thiodan, Sevin, Guthion, phosphamidon, Di-Syston, Imidan, Temik, and Thimet.

Flea Beetles

Tuber Flea Beetle (*Epitrix tuberis*), Western Potato Flea Beetle (*Epitrix subcrinita*)

There are several species of small, dark, leaf feeding beetles that attack potatoes. They are called flea beetles because they have well developed legs that allow them to jump like fleas. Four species are particularly important as potato pests. In the West, the tuber flea beetle and the western potato flea beetle may be important in some seasons. Flea beetles damage the foliage by chewing small holes in the leaves resulting in a shot-hole appearance. Larvae of the flea beetles attack the potato tuber and roots.

FLEA BEETLE

Adult flea beetles stay in or near fields in which they matured. They burrow several inches into the ground, sometimes well below plow depth. Flea beetles leave the overwintering sites as temperatures warm in the spring. Early feeding is done on weeds prior to emergence of the first potato plants. One to four generations may develop during the season. Eggs are deposited in soil cracks and hatch within 10 days. The entire life cycle may be completed in 4-6 weeks.

Control

Good weed control around field margins and within fields will help keep flea beetle numbers low. If chemical treatment is required, the following products are registered: Temik, Di-Syston, Thimet, Metasystox-R, Sevin, parathion, thiodan, Monitor, Dasanit, Guthion, and Imidan.

POTATO LEAFHOPPER

Leafhoppers

(Several species)

These relatives of the true bugs damage potatoes by sucking the sap mostly from the underside of the leaves. Several species of leafhoppers attack potatoes, the potato leafhopper being an important one. The feeding activity of the potato leafhopper may cause a virus-like disease known as "hopperburn", resulting in extensive stippling, curling, and browning of the leaves.

Leafhopper eggs are inserted into the tender parts of the plant in the spring and require 10-14 days to hatch. The nymphs mature into adults in about 16 days. There may be several generations per season (2-3 in the potato leafhopper). Populations periodically increase to epidemic proportions requiring application of an insecticide.

Control

Chemical control methods include Thiodan, malathion, methoxychlor, and Di-Syston.

Potato Psyllid

(Paratrioza cockerelli)

This psyllid can be a very destructive pest of potatoes. Uniquely, the damage done by this tiny insect is a secondary effect of its feeding activity. Like other types of plantlice, the potato psyllid is fitted with needle-like mouthparts for sucking plant juices. When it feeds on potatoes, the psyllid injects a substance into the plant which causes a curling and yellowing of the leaves known as psyllid yellows. This condition resembles leaf roll and aster yellows, but is caused only by the feeding of psyllid nymphs. In the advanced stages of feeding damage the plant becomes stunted, brown, and may die. The growth of tubers is stopped.

POTATO PSYLLID

Nymphs develop from eggs laid along the upper and lower leaf margins. Five instars are passed before the nymphs reach the adult stage. The potato psyllid does not overwinter in northern potato regions but instead, migrates to southern desert areas where it continues to breed throughout much of the winter. Migration occurs again in the spring with adults reaching Montana around May or June.

Control

Chemical control of the potato psyllid can be accomplished if populations require it. Some chemicals used are Di-Syston and parathion.

## Wireworms

WIREWORM

Many species of wireworms are also serious pests of potatoes. The greatest damage done by wireworms results from their feeding on developing tubers. They also attack seed pieces, roots and stalks which may necessitate replanting. Feeding holes made by wireworms may also serve as entry sites for other insects and disease.

Adult click beetles usually emerge in the spring and mate. Eggs are deposited in the soil and hatching wireworms (larvae) begin feeding. Most species of wireworms require 1-4 years to reach adulthood. Larvae spend most of the time in the top 3-4 inches of soil, but may go as deep as 30 inches to survive cold winter temperatures.

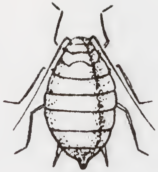
### Control

Chemical control includes the use of Dyfonate, Dasanit, Diazinon, Thimet and parathion.

## RAPE AND MUSTARD

### Aphids
(Several Species)

Aphids are common in rape fields but few species cause any damage. Control measures are more costly than the yield reduction caused by aphids. Several kinds of beneficial insects feed on the aphids and they too are common in aphid infested rape fields.



APHID

#### Control

Chemical control is seldom justified on mustard and rape for seed.

ARMYWORM

### Bertha Armyworm
(*Mamestra configurata*)

The large caterpillars of this pest feed on rape foliage and developing pods. The moths begin emerging about the middle of June. Their eggs are laid on the lower surfaces of the leaves and hatch in about a week. The caterpillars mature in the later part of August. They enter the soil to pupate and overwinter. One generation is produced each year.

#### Control

Currently no registered products for control of this pest on rape or mustard are available.

Cutworms
Pale Western (*Agrotis orthogonia*)
Red-backed (*Euxoa auxiliaris*)

The pale western and red-backed cutworm larvae cut host plant stems off just below the soil surface. The larger cutworms are usually found in the soil beside the freshly cut plants. Overwintering occurs in the egg stage. The newly hatched worms feed first on weeds and volunteer plants. Pupation occurs in late June with the adult night-flying moth emerging in August.

CUTWORM

Clover Cutworm
(*Scotogramma trifolii*)

A climbing cutworm with variable coloration, this pest usually occurs in small numbers in rape fields. The first generation moth flies in June, the second in August. The insect overwinters in the soil in the pupal stage.

Control

Presently no products are registered for control of cutworms on rape or mustard.

Diamondback Moth
(*Plutella maculipennis*)

Damage from this pest occurs when the caterpillars peel the bark from filling and maturing seed pods. The caterpillar is small, not over ½" in length, smooth, and pale green in color. They feed on foliage, blooms, and pods. The pupal stage is spent in an open lacework cocoon spun anywhere on the plant. The moth is small, drab brown in color, with a series of merged diamondshaped figures along the back. Overwintering occurs as an adult moth and this pest has three generations per year.

DIAMONDBACK MOTH

Diamondback Moth (Cont.)

Control

Thiodan 3EC is currently registered in Montana for control of Diamondback Moth, on rape and mustard.

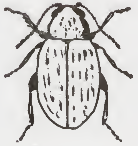
Loopers
Cabbage Looper (*Trichoplusia ni*)
Alfalfa Looper (*Autographa californicea*)

These caterpillars move by a looping motion and various species have been known to be pests in rape fields. Loopers spin a wooly cocoon on the plant which is partly enclosed by foliage. They are active about the time the crop is blooming and forming pods.

LOOPER

Control

Currently no products are registered for control of this pest on mustard or rape.



FLEA BEETLE

Flea Beetles
(*Phyllotreta cruciferae* and others)

Flea beetles are tiny insects which jump quickly when disturbed. They overwinter as adults in debris beneath the snow, becoming active in the spring. They begin feeding on volunteer rape, mustard or cruciferous weeds and later attack newly germinated rape and mustard crops. The beetles mate and lay their eggs during May and June, and the adult population begins to die off in late June. The eggs hatch into small larvae which inhabit the soil and feed on the host plant roots. By July or August the new generation of adult beetles has developed and begin emerging from the soil.

Flea Beetles (Cont.)

The most serious damage is caused by the overwintering adult beetles attacking seedling crops in May and June. Damaged seedlings have a typical "shot-holed" appearance. Once a crop gets beyond the seedling stage, serious damage does not usually occur.

Control

Thiodan 3EC is currently registered in Montana for control of Diamondback moth on rape and mustard.

# SAFFLOWER

## Aphids

Aphids, including the green peach aphid (Myzus persicae), the leaf-curl aphid (Aphis helichrysi) and the black bean aphid (Aphis fabae) can damage safflower seedlings and small plants. Aphids concentrate on the terminals of the plants and damage buds. Extreme populations will stunt plants and eventually kill them. The black bean aphid is the most injurious species attaining populations of 1200 or more per plant.

APHID

### Control

The following chemicals are registered for control of aphids on safflower: Malathion, Meta-Systox and Thiodan.

## Grasshoppers (Melanoplus spp.)

Several species of grasshopper may attack safflower in mid and late season. Damage is usually confined to field margins.

GRASSHOPPER

### Control

The following products are registered for control of grasshoppers on safflower: Cythion and Malathion.

## Leafhoppers

Leafhoppers (Empoasca spp.) can often become numerous in safflower fields. Feeding damage appears as stippling of the leaves. This type of feeding damage does little to affect the general health of the plant and treatment is seldom necessary.

LEAFHOPPER

## Loopers

LOOPER

The larvae of the cabbage looper (Trichoplusia ni) as well as several other caterpillar pests occasionally attack safflower. Damage is done to the foliage seed heads and seed. Populations seldom reach treatment levels.

### Control

The following products are registered for the control of loopers and armyworms on safflower: Dipel, Dylox.

## Lygus Bugs

Lygus bugs (Lygus spp.) may attack seeds and seedlings of safflower. Infestations are seldom serious enough to require treatment.

### Control

The following products are registered for control of lygus on safflower: Cythion, Dylox, Metasystox, Proxol and Supracide.

LYGUS BUG

## Wireworms

The larvae of click beetles (Limonius spp.) may attack safflower seeds and seedlings. Infestations are seldom serious enough to require treatment.

WIREWORM

### Control

The following products are registered for control of wireworms on safflower: Lindane (as a seed treatment).

Aphids
Western Wheat Aphid
(Brachycolus tritici)

Overwintering colonies of this aphid infest wheat plants in the spring. The injury starts early with thickening of leaves and broadening of the leaf blade. Longitudinal whitish, and later pinkish stripes appear on the leaves. Shortly before heading the leaves curl around the central stem making it difficult for the heads to emerge from the boot. This results in head distortion. Cultural control is recommended. Keep summer fallow clean of volunteer grains and grasses which act as overwintering sites for aphid colonies.

APHID

English Grain Aphid
(Macrosiphum Avenae)

Although normally causing no economic damage, under favorable conditions this bright green, black legged aphid can rapidly increase, causing heavy infestations in wheat. The aphids attack the leaves in the fall and the heads in the spring. In the dough stage, wheat can withstand heavy head infestations, but some shriveling and loss of weight may result when the infestation catches the wheat in the milk stage. Control of this pest is not normally required.

Control

Should chemical control be required to control aphids, the following products are registered: Di-Syston, Thimet, dimethoate, parathion, malathion, Penncap-M.

ARMYWORM

Armyworm
(Pseudaletia unipuncta)

These caterpillars are greenish with a pattern of stripes and appear later than the cutworms. They are voracious feeders which destroy green heads.

Armyworm (Cont.)

Control

Control methods include use of one of the following: Dylox bait, toxaphene, Thiodan 3 EC, Endrin, malathion, and parathion.

Cutworms
Army cutworm - *Euxoa auxiliaria*
Pale western cutworm - *Agrotis othogonia*

Both species are often found feeding on winter wheat in the spring. The army cutworm is a surface feeding cutworm, hiding in soil cracks during sunny days and emerging to feed on dark cloudy days and in the evenings. They feed largely on the tops of plants but will eat them to the ground on occasion. The pale western cutworm is a subterranean species preferring to feed on plants from the bottom up, starting with the roots and gradually pulling the stem down.


CUTWORM

The army cutworm has one generation a year, overwintering as a partly grown larva. The eggs are laid singly in or upon the soil. The pale western cutworm overwinters in the egg stage. The eggs hatch during warm periods during the winter or early spring and the single generation of larvae have usually completed their feeding by the end of June.

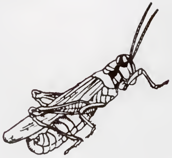
Control

Surface feeding cutworms like the army cutworm are somewhat easier to control because of the surface feeding habits.

Chemicals registered for cutworm control include: Endrin, toxaphene, parathion, and thiodan.

Grasshoppers
(*Melanoplus spp*)

All grasshoppers are not economic pests. Many are known to feed on weeds and other undesirable plants. In Montana, we have five major species of grasshoppers responsible for most economic damage. These



GRASSHOPPER

include the migratory, the two stripped, the red-legged, the differential, and the clear winged grasshoppers.

Overwintering occurs in the egg stage with the young nymphs becoming active in early spring. Grasshoppers undergo simple metamorphosis with adults mating and ovipositing in mid-summer.

Field margin and rough areas such as fence rows are preferred breeding and egg laying areas. There is one generation per year.

A number of mortality factors act to keep grasshopper populations under control. Included in these factors are weather conditions, predators, parasites, and diseases.

Control

Chemical control is still a recognized treatment for large grasshopper infestations. Applications should be timed so the majority of grasshoppers are in the fourth nymphal instar. The most effective control is obtained by the treatment of the nymphal hatching areas. Adult treatment is not as effective because egg laying has begun and principal damage to the plants has been done.

Treatment of winter wheat fields at planting may be justified if fall populations of grasshoppers are evident in the immediate area. Check border areas 7-10 days prior to planting. If grasshopper numbers warrant treatment, the outside drill rows can be treated with an approved systemic insecticide to protect the newly emerging seedlings.

Chemicals registered for grasshopper control on small grains include: Malathion, Endrin, parathion, methyl parathion, Thimet, and toxaphene.

False Wireworms
(*Eleodes spp.*)

Larvae of these beetles (*Eleodes*) often cause damage to seedling winter wheat. Several species are present in Montana. Adults emerge from pupae in August and lay eggs both in the fall and again in the spring. Newly hatched fall larvae feed until cold weather sets in. Overwintering occurs in various stages of development. The greatest damage occurs in fall seedings. Seed treatment will aid in the control of these insects.

False Wireworms (Cont.)

Control

Chemical control includes the use of Heptachlor as a seed treatment.


HESSIAN FLY

Hessian Fly
(Mayetiola destructor)

This grain insect has two generations per year. One attacks wheat in the fall, stunting plants and making them subject to winter kill. The second generation attacks in the spring resulting in dead tillers, broken straws, poorly filled heads and reduced yields. Adjustment of planting times (late seeding) and the use of resistant varieties of wheat offer the best control of this pest.

Control

Chemical control is not usually recommended, however, two products are registered for planting time treatment only: Di-Syston and Thimet.

BROWN WHEAT MITE

Brown Wheat Mite
(Petrobia latens)

The brick-red eggs of these mites overwinter in the soil, hatching in the spring. Young mites begin feeding on the leaves of winter wheat and range grasses. Several generations may develop per season, depending on weather conditions. They are usually controlled by environmental factors and treatment rarely becomes necessary.

Control

Should treatment become necessary the following products are registered for mites on cereal grains: Disulfoton, Methyl parathion, parathion, and systox.

## Plant Bug

The Pacific grass bug (Irbisa pacifica) and the black grass bug (Labops hesperius) are grayish black in color and about ¼" long. Feeding causes pale spots on leaves of cereals and if feeding is severe, leaves have a general yellowish stippled appearance. These insects rarely reach levels requiring treatment in Montana.

PLANT BUG

### Control

Chemicals registered for plant bug control include: parathion, methyl parathion, and malathion.

THRIPS

## Thrips

Several species of thrips may be found infesting grain from time to time. Thrips are black, yellowish, or reddish insects about 1/16" long. Their feeding causes foliage to turn whitish or rusty. If abundant, they may damage flowers and reduce yields. Thrips are seldom a problem in Montana grain fields. No insecticide treatment is recommended specifically for thrips.

## Wheat Jointworm

The adult jointworm (Harmolita tritici) wasp lays its eggs early in the spring in succulent wheat stems. The newly hatched larvae develop cells or galls in the wall of the stem just above the second or third joint from the ground. As the larvae develop, the galls become hard and brittle, making the stem highly susceptible to lodging. Larvae overwinter in the plant cells and pupate. Adults emerge in the spring through small holes which they gnaw in the stem wall. Grain kernels found on

WHEAT JOINTWORM

Wheat Jointworm (Cont.)

infested plants are small and lightweight. Control is not recommended in Montana due to the small percentage of plants attacked.

Wheat Stem Sawfly

The wheat stem sawfly (*Cephus cinctus*) is a native insect which lives in larger stemmed grasses including spring wheat. The larvae of this pest spend the summer within the stems, filling them with frass (sawdust like cuttings), causing the straws to break. Continuous wheat cropping increases the probability of an infestation. Control is best achieved by planting solid-stemmed varieties of wheat.


SAWFLY

Wheat Stem Maggot

The larvae of the wheat stem maggot (*Meromyza pratorum*) infest wheat, barley and rye plus many species of native grasses. The maggots feed inside the top node. The heads of infested plants appear to be ripening while the remaining plants in the field are still green. Infested heads turn white and stand more erect than uninfested plants. Larvae pass the winter in stubble and straw. Adults emerge in June and deposit eggs on the leaves of host grasses. Fall plowing and straw cleanup helps keep populations low. Planting should be delayed until after the fly free date.

Control

Chemical control of this pest is not recommended because infestations are seldom severe enough.

Wireworms
(*Ctenicera pruinina*) and others

When the spring weather remains wet for a long period of time, wireworms (click beetle larvae) may be very destructive to wheat, barley, oats and rye. Larvae are up to 3/4" long, yellowish and smooth bodied. Kernels and seedlings are attacked. Bare spots in fields show up and continue to enlarge, necessitating reseeding in some instances. Wireworms may persist in a field for several years. Seed treatment may be necessary when planting fields with a history of wireworm infestations.

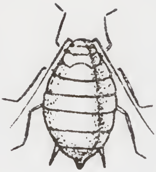

WIREWORM

Control

When treating, use seed treatment only: Lindane, Heptachlor.

## Aphids

Several species of aphids, including the green peach aphid (Myzus persicae), the melon aphid (Aphis gossypii), and the black bean aphid (Aphis fabae) may be important in sugar beet fields as vectors of viral diseases. In some growing areas, a preventative treatment program for aphid control may be necessary to prevent buildup of viral diseases.



APHID

### Control

Chemicals registered for aphid control on sugar beets include: parathion, Trithion, Systox, malathion, Diazinon, Di-Syston, Temik, Thimet, and Thiodan

## Armyworms

Beet armyworm (Spodoptera exigua) and bertha armyworm (Mamestra configurata) can be damaging to sugar beets. Larvae, variable in color, are about 1½-2" in length when mature. Damage is caused by their feeding on foliage.

ARMYWORM

### Control

Chemicals registered for armyworm control on sugar beets include: Dylox, parathion, Sevin and malathion.

## Cutworms

The variegated cutworm (Peridroma saucia) and the redbacked cutworm (Euxoa ochrogaster) are soil-dwelling caterpillars. Their color is variable from light brown to black. Cutworms generally feed at night and rest during the day. Mature larvae may

CUTWORM

Cutworms (cont.)

exceed 2" in length. Pupation occurs in the soil and the emerging dusky brown to gray moths are most active at night. Cutworms tend to be more troublesome in beet plantings that follow pasture, alfalfa, or clover crops.

Control

Chemicals registered for cutworm control on sugar beets include: Dylox, methyl parathion, and Sevin.

Loopers

LOOPER

The alfalfa looper (Autographa californica) is a slender dark green to light green caterpillar with a pale head and three dark stripes on the side. This caterpillar is primarily a pest of alfalfa but will attack the foliage of several other crop plants. Full grown larvae are 1-1½" long and crawl in a looping fashion. The alfalfa looper is a voracious feeder and can do a great deal of damage in a short time. There may be two or more generations per year.

Control

Chemicals registered for the control of alfalfa looper include: Dylox and parathion.

Leaf Miners

Leaf miners including Pegomya betae and Psilopa levostoma may be damaging to sugar beet crops during early and mid-season. Foliage damage in heavy infestations may retard plant growth and reduce yield. These leaf miners are white to yellowish maggots that make long winding tunnels or blisters beneath the leaf epidermis. The adults are small, slender, gray to black flies. Leaf miners seldom reach treatment levels.


LEAF MINER

## Leaf Miners (cont.)

### Control

Chemicals registered for leaf miner control include: Parathion, Temik, and Thimet.

## Flea Beetles
(Several species)

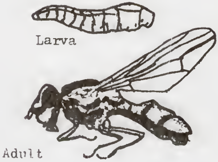

Flea beetles of several species will attack sugar beets. The tiny dark brown to black beetles overwinter as adults under plant debris and in soil cracks, emerging in early spring. Initial migration of flea beetles from roadsides and waste areas often coincides with sugar beet emergence. When this occurs, flea beetles can extensively damage the young beet plants.

### Control

Chemical control utilizes the following: Lannate, methyl parathion, and parathion.

## Sugar Beet Root Maggot
(*Tenanops myopaeformis*)

The maggot of this shiny black fly causes considerable damage to sugar beets by cutting off the taproot and feeder roots. Infested plants wilt and die. Eggs are laid in the soil around the beet plants and hatch into typical white maggots in a few days. Full grown maggots overwinter in the soil and pupate. Adults emerge in the spring. Irrigation to keep the maggots feeding above the taproot is the best control. Chemical seed treatment is also effective.

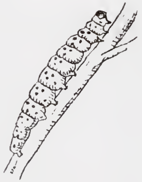



SUGAR BEET MAGGOT

### Control

Chemicals registered for sugar beet root maggot control include: Dasanit, diazinon, Dyfonate, Furadan, malathion, Temik, and Thimet.

Sugar Beet Webworm
(Loxostege sticticalis) and others



BEET WEBWORM

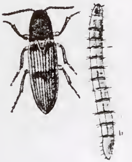
Several species of webworm attack sugar beets, the most important being the sugar beet webworm. These caterpillars are voracious feeders, attacking the beets around mid-season. They may cause serious damage to beet foliage within a few days. Webworms feed primarily on the underside of the leaves. Older larvae leave only the leaf veins as evidence of their feeding activity. Webworms pupate in the soil and emerge as greyish brown moths. Clean culture, destruction of weed hosts which harbor the worms, and deep plowing at the time of pupation help prevent injury.

Control

Chemicals registered to control beet webworms include: parathion, methyl parathion, Sevin, Dylox, Lannate, and Thiodan.

Wireworms

The larvae of click beetles (Limonius spp.) feed on the roots and bore holes into the sugar beet tubers. Female beetles lay 200-500 eggs in the soil that hatch in about 2 weeks. Full grown larvae may be 1½" long and live in the soil from 2-6 years before pupating and changing to the adult. Plant stands may be reduced by wireworm feeding on the seed and emerging plants. Later in the season, wireworms may cut or severely injure the taproot of the plant further reducing yields.



WIREWORM

Control

Culturally, wireworm infestations can sometimes be anticipated and reduced. Wireworms tend to build up in red and sweet clover, small grains and some truck crops. In contrast, a well maintained field of alfalfa will help reduce wireworm numbers because these insects are susceptible to dry soil conditions.

Wireworms (cont.)

Alfalfa tends to dry the soil out. If alfalfa fields are allowed to dry during the season and are removed from production, further reduction in wireworm numbers can be expected.

Chemicals registered for wireworm control include: Diazinon, Dyfonate, Telone, Terr-o-cide, and parathion.

## Sunflower Beetle

The adult sunflower beetle (*Zygogramma exclamationis*) resembles adult Colorado potato beetles and are often confused with this insect even though the sunflower beetle does not occur on potato nor the Colorado potato beetle on sunflower.

SUNFLOWER BEETLE

### Control

There are presently no registered chemicals in Montana for control of sunflower beetles.

## Girdlers

Female girdlers (longhorned beetles) girdle either around the stalk or around the head of sunflower and place one egg per plant just beneath the epidermis. Upon hatching, the larvae burrow into the pith and migrate towards the roots as development occurs. Girdlers overwinter as larvae in the roots with one generation per year. These pests do not interfere with seed development and their economic significance is low.

GIRDLER

### Control

There are presently no products registered in Montana for control of stem girdlers on sunflower.

WEEVIL

## Weevils

There are at least five species of weevils which have caused economic losses in sunflower. The "head clipper" (*Haplorhynchites aeneus*)

Weevils (cont.)

female makes one complete girdle just below the sunflower head. The girdled head subsequently falls to the ground where larval development and overwintering occur. Although there are no specific control measures for this pest, insecticides applied to control other insects also kill this species.

Severe stalk infestations by the larvae of two other weevils (Cylindrocopturous spp.) have also been noted. The larvae burrow into the stalk and lodging becomes the chief economic factor. Overwintering occurs as a larva in the ground and early planting is the best means of control at present.

Control

Supracide is registered for control of weevils on sunflowers.

Cutworms

The dark-sided and the red-backed cutworm (Euxoa spp.) can become major pests in the northern sunflower production area. Cutworm larvae which infest sunflower are brown to brownish white in color with characteristic markings which are used for identification. During the day the larvae lie under the surface of the soil, usually within 1-2 inches of the plant. The larvae are active at night and may feed below or above the soil surface, cutting off the plant at or slightly above the soil surface.

CUTWORM

Cutworm activity is greatest in May or June when the larvae hatch from overwintering eggs. The adult moth lays eggs in late July and early August and these remain dormant until the following spring. The darksided and the redbacked cutworms have one generation per year.

Cutworms (cont.)

Control

Presently no products are registered in Montana for control of cutworms on sunflower.

Sunflower Budworm

The presence of black frass extruding from larval entrance holes in both the stem and terminal areas of young sunflower signal the presence of the sunflower budworm (Suleima helianthana). Although injury by the larval feeding produces malformations of both the stalk and the head, yield loss has not been economically significant.

SUNFLOWER BUDWORM

The sunflower budworm overwinters as a larva in the stalks of sunflower and other plants. Adults emerge in late May. Two generations per year in northern climates.

Control

No control recommendations exist for the sunflower budworm at this time but the development of resistant hybrids appears promising.

Sunflower Moth

SUNFLOWER MOTH LARVA

Sunflower moth (Homeosoma electellum) may be the most devastating insect pest of sunflower. It is widely distributed throughout the U.S. and damage is most severe to sunflower planted before May 15-20. Females lay eggs among the florets. Most larvae emerge within 48 hours and feed primarily on the florets and pollen. Older larvae tunnel through immature seed and other parts of the head. A single larva may feed on from 3-12 seeds. Larval development is completed in 40-45 days. Injury to sunflower heads by the larvae of the sunflower moth may permit introduction of the fungus which causes head rot.

Sunflower Moth (cont.)

Moth activity in early planted fields prior to and during early July may justify chemical control measures. The need for insecticidal applications after mid-July is not known.

Control

The following chemicals are registered for control of the sunflower moth: Methyl parathion, Supracide, and Thiodan.

Banded Sunflower Moth

Flight of adult banded sunflower moths (Phalonia hospes) overlap those of the sunflower moth in mid-July. Larvae are off-white, pink or green and can be found in sunflower heads from late July to harvest. The banded sunflower moth feeds solely on the seeds with a single larva consuming from 3-5 seeds to complete development.

Control

Control of this insect has not been necessary. Insecticide applications initiated for control of the sunflower moth may also provide some control for the banded sunflower moth. No insecticides are currently registered for control of this pest.

PAINTED LADY BUTTERFLY

Painted Lady Butterfly

Infestations of the painted lady butterfly (Cynthia cardui) have been noted each year in sunflower. The larvae feed on the foliage of Canada thistle, soybean, sunflower and other plants. Larvae normally feed in the terminal region of the plant where one larva per leaf usually feeds under webbing in a curled leaf. Infestations rarely reach levels of economic importance.

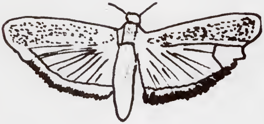
## Checkerspot Butterfly

Larvae of the checkerspot butterfly (Chlosyne lacinia) feed in large colonies of up to about 100 per leaf. This species has not caused significant damage to sunflowers grown in the North, but complete defoliation of plants has been reported in the South.

CHECKERSPOT BUTTERFLY

## Saltmarsh Caterpillar

The larva of the saltmarsh caterpillar (Estigmene acrea) has a ravenous appetite and causes economic losses in several crops each year. The larvae are migratory and may defoliate an entire field once a large invasion occurs. These sporadic pests may be controlled with early planting.



SALTMARSH CATERPILLAR

### Control

There are presently no chemicals registered for control of this pest on sunflower.

## Root-boring Moth

Larvae of the root-boring moth (Eulosoma womonana) burrow in the taproot primarily between the woody part of the root and the epidermis. Larvae may be detected by pulling dying plants, in which the dead epidermal tissue falls away.

### Control

There are presently no insecticides registered for the control of this pest.