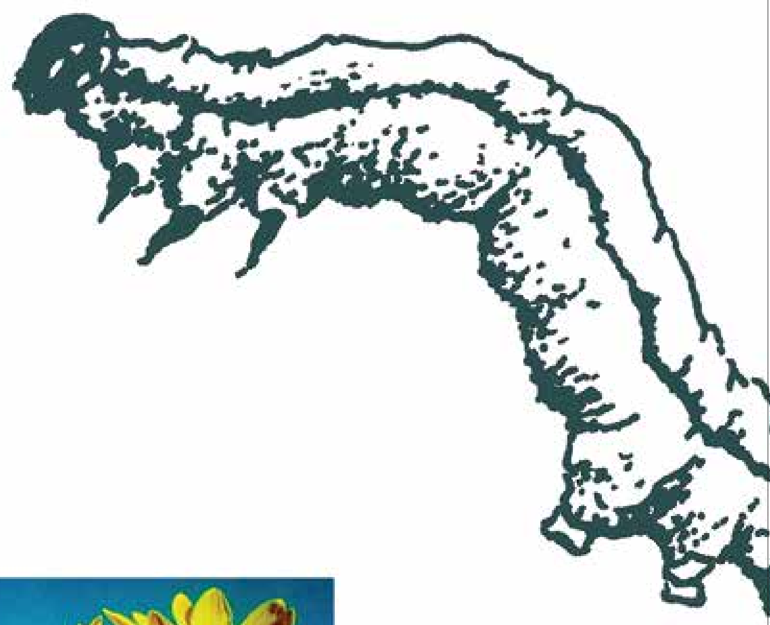
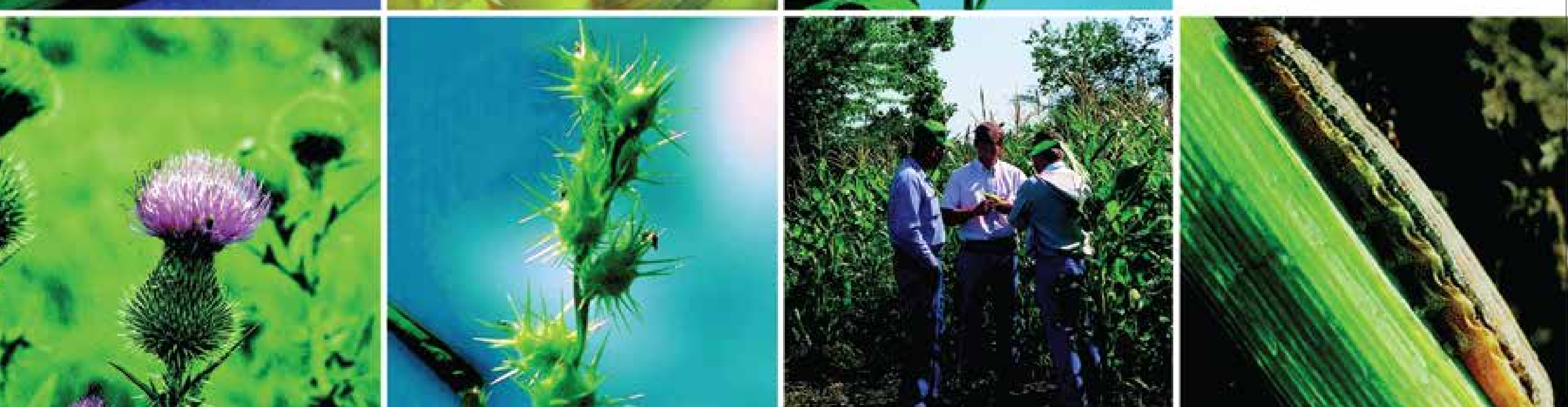
Vegetable

Integrated Pest Management Program - University of Wisconsin–Extension, Cooperative Extension Service

Crop Scouting Manual





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An Introduction to Integrated Pest Management

UW Extension

Definition

Integrated Pest Management (IPM) can mean different things to different people. As a result, definitions are diverse and have ranged from those which advocate mostly organic control to those which focus on chemical control. One commonly used definition that is easy to understand is the following:

IPM is a decision-making process that utilizes all available pest management strategies, including cultural, physical, biological and chemical control to prevent economically damaging pest outbreaks and to reduce risks to human health and the environment.

Important concepts of this definition include:

1) *is a decision making process...*

IPM is a continuum of management practices that range from simple field scouting to biointensive IPM which utilizes a systems approach to crop and pest management. Action thresholds have been incorporated into many IPM programs to assist with the decision making process. Two types of thresholds are commonly used:

Economic thresholds

have been developed for crops where yield in the primary concern. The economic threshold is that pest level at which control practices must be implemented to prevent economic damage (i.e. cost of control is less than expected damage).

Aesthetic thresholds

are used for crops such as fresh market vegetables, fruits and ornamentals where appearance plays a critical role in the crop's marketability. Aesthetic thresholds are subjective and not absolute. They are driven by consumer preference.

2) *that utilizes all available pest management tactics...*

IPM utilizes all available pest control tactics. IPM does not rely on a single tactic to control pests. Some of the problems that result when a single management tactic is used include pest resistance and secondary pest outbreaks. However, preventative non-chemical control tactics should be used, whenever feasible, as a first line of defense.

3) *to prevent economically damaging pest outbreaks*

and reduce risks to human health and the environment. IPM must continue to focus on economic, public health and environmental goals. Public health and environmental protection have been the foundation of IPM since its inception. However, the producer's profitability and livelihood has to considered in all management decisions. Finding the appropriate mixture can be difficult.

History of IPM

Although IPM has become a "buzz word" in recent years the concept has been evolving for a long time. In the early years of IPM, pest management was centered around the control of a single pest. This concept , called "Integrated Control", was introduced in the 1950's and used similar philosophies that are used today (i.e., conservation of natural enemies, proper selection of pesticide and host plant resistance). However, IPM differs from Integrated control in at least two areas:

IPM focuses on management not control.

The word control seems to imply that you have power over something and to many people means total eradication. Conversely, management implies a less threatening method of dealing with pests.

IPM is concerned about the whole cropping system.

Integrated Control dealt with the management of a single pest species. Consideration must be given to how one management practice impacts other components of the system. For example, crop managers are concerned about the frequent use of fungicides for disease control in potatoes because their use can increase aphid populations by inhibiting natural fungal pathogens of the aphids.

Components of an IPM Program

One of the major components of an IPM program, if not its foundation, is crop scouting. The goal of crop scouting is to provide accurate and unbiased pest and crop development data. Without this information an intelligent pest management decision cannot be made. A crop advisor must have a thorough understanding of crop growth/development, key pests and their life cycles. Additionally, the crop advisor must know how the environment affects each of these components. Only after this information is collected can an appropriate pest management decision be made.

Pest prevention is another key component of an IPM program. This implies that action be taken against the pest before economic damage is reached and in some cases before a pest problem is even detected. This can be accomplished in a number of ways including physical, cultural and biological controls. These practices should be implemented prior to the use of therapeutic controls (i.e. chemical control). Therapeutic controls are recognized as a necessary component of IPM programs. However, all appropriate non-chemical control options should be implemented before pesticides are recommended.

Multi-disciplinary research and education, are also necessary components of an IPM program and are required to move IPM along the continuum. Although IPM has achieved significant accomplishments, it has a long way to go. Without the above components, IPM will continue to be a management system that is chemically based. As new management methods become available they must be worked into existing programs through education. IPM programs should not be viewed as static; they are constantly changing. What is considered an IPM program today may be considered out dated technology in three years. Growers and crop advisors must be ready and willing to adapt new technologies into their farming enterprise.

Collecting and Submitting Plant Disease and Insect Specimens

UW Extension

Proper disease and insect identification requires two basic steps:

1. Gathering the pertinent background information. Detailed use of the submission form is necessary.
2. Studying the affected plants properly; and properly collecting and submitting plants to a diagnostic laboratory when this is necessary.

Suggestions for collecting and submitting plant specimens:

1. Whenever possible, you should collect the specimens yourself, so that you can examine the field or crop area concerned, and can examine healthy as well as diseased plants.
2. Examine all parts of the plant(s), including the roots if at all possible.
3. Dig plants—do not pull them.
4. Send immediately after digging—do not let plants lie around for a period of time before packaging and sending.
5. Send in the entire plants when feasible. **
6. When possible, submit plants or plant parts showing the range of symptoms—healthy, slightly and seriously affected.
   ** Remember leaf abnormalities are often symptomatic of a problem in some other part of the plant.
7. See directions for packaging on the following pages
8. Collect and send specimens during the early part of the week to reduce the chance of weekend delay and deterioration.
9. Submitting Insect Specimens for identification.

A) For Beetles and True Bugs. Place dead specimens in a clean, small vial. Within twelve hours after death insects become very dry, hard and brittle. Appendages such as antennae, which are important characters for identification, are easily broken. Cotton or tissue paper inside the mailing tube will cushion the specimen in transit, and increase the chances of the specimen arriving in one piece.

B) Adult moths, mosquitoes and other insects covered with fine scales or hairs should be kept dry. Proper identification is very difficult if scales or hairs are rubbed off. Again, handle with care, and use some form of "padding" for shipment, after placing specimen in a vial.

C) For Caterpillars and other worms and maggots. The simplest and best method of killing these larvae is to drop them into very hot or gently boiling water and then transfer them immediately to alcohol. This will preserve both their shape and color (color is often an important character for species determination). Alcohol alone may be used as a killing agent, but it may cause discoloration. Seventy percent ethanol is the best liquid preservative, but rubbing alcohol (which is available in local drugstores) is satisfactory. Both aftershave lotion and clear cocktail alcohol such as gin will work in a pinch.

D) Small soft bodied insects such as aphids or leafhoppers should be put directly into and shipped in alcohol.
Glass or plastic prescription bottles (often available in quantity from local pharmacists) make good storage containers only if they are sealed to prevent leakage and if they are packed within a sturdy box or mailing tube. The mails are very rough on unprotected glass.

The recommendations for submitting insect damaged plant material are the same as for diseased specimens.

Packing Specimens for Submission

Pack all specimens in outer carton with packing so they do not bounce around. Mail early in the week so packages do not sit in post office over a weekend.

Potted Plants

Place pot into plastic bag.
Secure around base of stem with straws or twist 'em.

Entire Plant

Wash roots.
Wrap roots in paper towel and then in plastic bag and secure around base of plant.
Aerial portion in flat position in alternate layers of moist (not wet) and dry newspaper with moist layer next to plant.

Aerial Portion of Herbaceous Plant

Lay as flat as possible between layers of newspaper.
Layer next to plant may be slightly moist.
Use cardboard for outer layers.

Single Leaves

Press flat between alternate layers of moist (not wet) and dry layer next to leaf.
Cardboard for outer layers.

Fleshy Fruits and Vegetables

Wrap in dry newspaper.
Place in perforated plastic bag.

Where to Go for Help in Diagnosing Plant Problems

Following is a list of plant diagnostic services currently available and, in most cases the cost of tests (1997 prices) is included. The services are listed by institution.

UW-Madison Extension Specialists Plant Identification and Culture

Agronomic and Horticultural Crops

Corn: Joe Lauer (263-7438)

Forage Crops: Dan Undersander (263-5070)

Soy Beans & Small Grains: Ed Oplinger (263-7436)

Flowers: Department of Horticulture (262-1490)

Forest trees: Ted Peterson (262-0249),
Jeff Martin (262-0134)

Fruit: Teryl Roper (262-1490)

Turf: John Stier (262-1624)

Vegetables: Helen Harrison (262-1749)

Weeds

Corn and small grains: Chris Boerboom (262-1392)

Alfalfa: Jerry Doll (263-7437)

Vegetables: Larry Binning (262-1689)

Turf: John Stier (262-1624)

Woody Ornamentals: Laura Jull (262-1450)

Vertebrate pests: Scott Craven (262-6325)

Soil Fertility and Management

Department of Soil Science (262-2633)

Corn and soybeans: Larry Bundy (263-2889)

Forages and small grains: Keith Kelling (263-2795)

Vegetable crops: Larry Bundy (263-2889)

Lawns and gardens: Wayne Kussow (263-3631)

Irrigation and drainage: Leonard Massie (262-0604)

Waste application to soils: Keith Kelling (262-2631)

Analytical services

Plant analysis: Sherry Combs (262-4364)

Forage analysis: John Peters (715/387-2523: Marshfield lab), Sherry Combs (262-4364)

Soil analysis: Sherry Combs (262-4364), John Peters (715/387-2523: Marshfield)

Extension Entomologists Insect Identification

Entomology Dept., UW-Madison
237 Russell Laboratories, Room 240,
Madison, WI 53706-1598;

(608/262-3227)

General diagnostic assistance, nuisance pests, structural pests: Phil Pellitteri (262-6510).

Agronomic crop pests, stored grain pests: John Wedberg (262-3226).

Vegetable pests: Jeff Wyman (262-3229).

Fruit Pests: Dan Mahr (262-3328).

Directions for collecting and mailing specimens are available form the laboratory mentioned above. Submit as much information with specimens as possible: such as where found, the environment and host. Insects should be preserved in alcohol (rubbing alcohol works) & properly packed for mailing.

Extension Plant Pathologists Plant Disease Identification

Plant Pathology Dept., UW-Madison
283 Russell Laboratories
Madison, WI 53706-1598

(608/262-1410; Fax 608/263-2626)

General diagnostic assistance: Brian Hudelson (262-2863).

Vegetable crop diseases: Walt Stevenson (262-6291).

Fruit diseases: Patricia McManus (265-2047).

Agronomic crop diseases: Craig Grau (262-6289).

Note: Directions for collecting and mailing specimens are available form the laboratory mentioned above, as well as a plant identification form. This form must accompany any suspect plant disease specimens submitted to extension plant pathologist. Diagnosing disorders caused by fungi, bacteria, viruses, and phytoplasmas generally requires fresh or recently diseased plant materials. Thus, submit representative materials promptly.

1998 Fees for Diagnosis

The Plant Pathogen Detection Laboratory accepts samples for diagnosis through the county extension office. If the county agent prefers the samples may be sent directly and we have a special form for use by the professional in these cases.

In order to recover some of the costs incurred in the diagnosis process we have been charging since July 1, 1985. Please call prior to sample submission to confirm pricing and available tests. (608) 262-2863.

Regular samples*	$10.00
Ginseng samples	.$18.00
Potato Ring Rot Test	$25.00
DAPI tests for MLO's	$30.00
Electron Microscope work	$180.00
Tissue sent to AGDIA for Virus analysis	$30.00
Soil Test for *Pythium* or *Phytophethora* or *Aphanomyces*	$25.00
P Root Rot Test	$50.00
PCR Test for Phytoplasmas	(Inquire at clinic for availability)

*Additional costs may apply if other tests are necessary.

Lab will confirm prior to additional testing.

Nematode Analysis

Ann MacGuidwin
Nematode Diagnostic Lab, UW-Madison
1630 Linden Drive, Room 491
Madison, WI 53706-1598

(608/263-6131; Fax 608/263-2626)

Root & Soil Analysis	$22.00
Soybean Cyst & Corn Needle Analysis	$14.00

Soil Analyses for Verticillum Propagules

Pest Pros
P.O. Box 188
Plainfield, WI 54966

(715/335-4046) Call for price

Dr. Douglas Rouse
1630 Linden Drive, Room 395, UW-Madison
Madison, WI 53706-1598

(608/262-1395; Fax 608/263-2626)

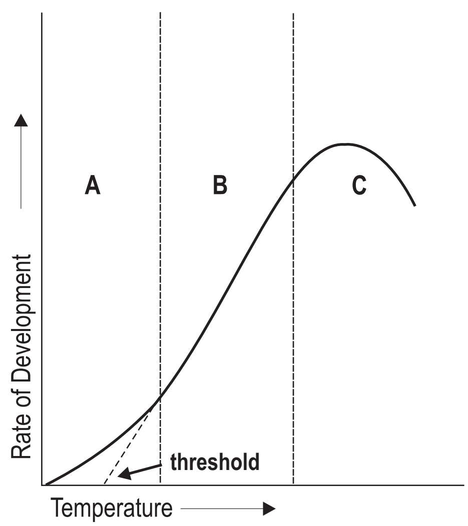
Degree Days — What Do They Mean?

David Hogg, Entomology

Degree days (also known as “day-degrees” or generically as “heat units”) provide a means of predicting insect phenology (i.e., the timing of life history events) by combining time and temperature to measure insect development and activity. The utilization of degree days is becoming increasingly important in insect pest management programs, due to the potential for increased accuracy over calendar time in predicting phenological events. Applications to pest management include the scheduling of pest scouting and in some cases insecticide applications or other types of control tactics.

Theoretical Basis

The degree day concept is based on the fact that insects are cold-blooded, and thus an insect’s body temperature is similar to the temperature of the surrounding environment. As a result, the physiological activity of insects is governed largely by environmental temperature. This is illustrated most vividly in the case of the development of the immature stages of insects. The relationship between the rate of immature development and temperature is shown in a general way in the figure below.



For convenience, the relationship has been divided into three regions. In B, the relationship between developmental rate and temperature is linear. In A, the relationship begins to deviate from linearity, and as cooler temperatures are encountered the rate slowly approaches zero (no development). In C, the relationship also begins to deviate from linearity, and as warmer temperatures are encountered, the rate reaches a maximum and then begins to decline.

Temperatures in the linear portion of the temperature-rate relationship generally are the most favorable for insect survival and development, and in most cases the life history of an insect species is geared so that the insect is active when temperatures in this region are encountered most commonly. Although higher temperatures (region C) may promote faster development, prolonged exposure to these conditions usually results in excessive mortality.

In developing a degree day scale, the linear region of the temperature-rate relationship is utilized. The assumption is made that the relationship remains linear in region A, and a base temperature or “developmental threshold” (i.e., the temperature below which no development is assumed to occur) is determined by extrapolation of the linear relationship (see figure). The importance of assuming linearity is that, by so doing, the number of degree days required to complete development will be the same regardless of temperature. Of course, the details of the temperature-rate relationship will vary depending on the insect species; for example, the pea aphid has developmental threshold of about 38°F, whereas the corn earworm has a threshold of about 56°F. The threshold an degree day requirements for each species and stage of interest can be determined experimentally.

Calculating Degree Days

A degree day can be defined as one degree of temperature above the threshold for one day. There are several methods available for calculating degree days. The easiest is to use the high and low temperatures for the day, calculate an average temperature, and subtract the threshold:

[(High + Low) / 2] – Threshold = Degree Days for one day

For example, if a threshold of 50° is used, and a high of 80° and a low of 60° have been recorded, the number of degree days for the day would be:

[(80 + 60) / 2] – 50 = 70 – 50 = 20

This procedure is accurate as long as the low temperature is greater than or equal to the threshold. However, if the low temperature is less than the threshold, this procedure underestimates the actual number of degree days. When this occurs, there are several other methods available for calculating degree days. One of these is known as the “modified” degree day method, in which the low temperature is set equal to the threshold whenever the low is less than the threshold, and degree days are calculated as before. A drawback to this method is that it tends to overestimate the actual number of degree days. A more accurate procedure is known as the “sine wave” method. A sine curve is fit through the daily high and low temperatures, and the area under the curve and above the threshold equals the number of degree days. The sine wave method is also the most difficult to calculate, requiring a computer or at least a programmable calculator. One approach to overcome computational difficulties is to prepare a table that gives the number of degree days above some threshold temperature for every possible combination of high and low temperatures. Daily degree day accumulation can then be determined simply by referring to the table.

On a seasonal basis, degree day accumulation (a process known as "thermal summation") normally starts the first day the temperature goes above the developmental threshold. After that, a running total of accumulated degree days is kept.

Applications

For degree days to be useful in a management program for a particular insect pest, two criteria must usually be met. First, the pest must overwinter locally; in Wisconsin this is accomplished by hibernation in a physiological condition known as diapause. Examples of insect pests that are unable to survive the winter in Wisconsin are the potato leafhopper and the corn earworm. These species overwinter only in areas well to the south of Wisconsin, and each year both migrate into the state. Usually the potato leafhopper arrives during May and the corn earworm arrives during August, but the arrival times of migrants are not predictable enough to calibrate with degree day seasonal totals. The second criterion is that the pests have discrete generations. For example, the pea aphid overwinters in Wisconsin; however, the aphids have very short generation times and reproduce continuously, so that in a short time the generations overlap. As a result, all aphid stages are present in the field during virtually the entire growing season, and aphid abundance is related to factors other then degree day totals.

Two pest species that meet both criteria and for which degree days have proven useful in management programs are the alfalfa weevil and the European corn borer.

The alfalfa weevil is a pest of first crop alfalfa in Wisconsin. It overwinters in the adult stage. In the spring the adults come out of hibernation, feed and lay eggs. It is feeding by the larvae that hatch form these eggs that can cause significant damage to the crop. Only one generation of larvae occurs each year, and it either is completed by the time the first cutting is taken or is interrupted when the field is cut. The developmental threshold of the alfalfa weevil is 48°F. In southern Wisconsin damaging populations of weevil larvae do not occur until a seasonal total of at least 300 degree days above 48°F has been accumulated; thus, in southern Wisconsin it is recommended that scouting for alfalfa weevil be initiated when a total of 300 degree days is reached.

The European corn borer is a pest of field and sweet corn in Wisconsin. The corn borer overwinters as a mature larva. In the spring the larvae pupate, emerge as adults, and lay eggs. Two discrete generations of this pest are normally completed during the growing season in southern Wisconsin. The developmental threshold of the European corn borer is 50°F. Seasonal degree day (DD) totals above 50°F for various events in the seasonal history of the corn borer in southern Wisconsin are given in the following table:

First (Spring) Generation	**DD**
First moth	374
First eggs	450
Peak moths	631
Treatment period	800-1000

Second (Summer) Generation	**DD**
First moth	1400
First eggs	1450
Peak moths	1733
Treatment period	1550-2100

The values in the table represent averages of 5 years of data collected by J.W. Apple (formerly of the U.W. Entomology Department) at the Arlington Experimental Farm. Also shown in the table are the periods during which insecticides should be applied if treatment is warranted; the timing of treatments is important because once corn borer larvae bore into the plant, they are no longer vulnerable to insecticide applications.

Conclusion

Degree days, by combining time and temperature, provide a much more accurate means of measuring insect activity and development in the field than does calendar time alone. Because of this capability, degree days can be useful in the development of management programs for certain insect pest species.

There are, however, several potential problems in using degree days that should be mentioned. As discussed earlier, the degree day concept is based on the linear portion of the temperature-rate relationship. If temperatures are consistently either above or below the linear range, errors in prediction are likely to arise. Another potential problem is that temperatures used to calculate degree days generally are ambient (air) measurements, whereas the temperatures in the insects' microenvironment may be quite different than ambient. However, in most cases, degree day scales are calibrated in the field, so that discrepancies between microenvironmental and ambient conditions are accounted for in the scale. Finally and most pragmatically is the problem of where to obtain temperature data for calculating degree days. Ideally, temperatures should be recorded in or near the field where the pest population of interest occurs. Unfortunately, often this is not possible. The only advice that can be offered is that preliminary measurements be made to ensure that conditions between locations do not deviate significantly. Otherwise, there is the danger that the "wrong" temperature will be used.

Using Pheromone Traps

Trapping is very important to any monitoring and pest management program. In addition to using blacklight traps to monitor insect activity in various crops, pheromone traps are also very useful. Unlike the blacklight trap which uses light to attract nocturnal insects, pheromone traps use "odors" or pheromones to attract insects. In nature, pheromones are secreted by insects to alert other insects to specific conditions. Sex pheromones, aggregation pheromones, alarm pheromones, and trail pheromones are the more common chemicals used to communicate in the insect world.

Science has found a way to synthetically produce pheromones, primarily sex pheromones which are used by the female of the species to attract a mate. These are used in conjunction with specially designed traps to lure specific insect species to the trap. At this time, over 60 different pheromones are available commercially to aid in pest monitoring. Vegetable insects that can be monitored with pheromone traps include armyworms, black cutworm, cabbage looper, corn earworm, diamondback moth, and variegated cutworms. The most common vegetable pest monitored with a pheromone trap is the corn earworm. Diamondback moths can be monitored with pheromones as easily as the corn earworm, however most growers haven't begun to utilize this very useful monitoring tool. Work continues to be done on developing a suitable lure for the European corn borer but at this point, there is nothing available to growers and crop consultants.

Trapping will take time and additional knowledge to implement. You must learn which type of trap to use, where and when to place the trap, which pheromone lure to use, how often to check the trap, and what trap catches mean. However, trapping will save you money in the long run by indicating whether you actually have an insect infestation and whether it is severe enough to require treatment. Trapping will also help you time your treatment efforts to the most susceptible life stage of the pest. By trapping the adult insects, you will realize you have a pest problem long before the damaging larvae are present.

It is important not only to use the appropriate lure specific to the pest you want to monitor but also to use the correct trap. Pheromone traps may be sticky traps such as the delta or winged traps used to monitor gypsy moth and other tree or orchard pests. Some insects such as Japanese beetles and corn earworm moths require specifically-designed traps. For example, corn earworm moths must be trapped in a specialized wire mesh trap called a Hartstack trap.

Traps should be in place at least 2 weeks before the earliest known emergence of the insect in your area. UWEX specialists can help you determine when you should set out your traps. Once the traps have been set up, they should be checked for insects at least twice a week. Once insects appear in the trap you should tighten up your monitoring schedule to at least every other day so you don't miss population trends and peak emergences. Record the number of moths caught at each visit so you have something tangible to refer to at a later date if needed.

Location of the trap is also important. Ideally, every susceptible field should have a pheromone trap located in, or near, it. For example, if you are trapping corn earworm moths, you should have an earworm trap in every silking sweet corn field. Traps should be placed level with the crop canopy "up wind" at the field edge so that the pheromone can be dispersed through the field. Lures (plastic or rubber strips impregnated with the pheromone) should be kept in the freezer until ready to use and never exposed to heat. They should be changed according to package directions, for earworm this is every 2 weeks. Because there will still be some pheromone left on the lure you should be careful to remove the old lure from the field and properly dispose of it along with the packaging material for the new lure, in the trash. Do not drop the used lure in the field as there is enough pheromone remaining to attract (and confuse) the moths.

UWEX publications and specialists will provide information on interpreting your trap catches based on the type of pest you are monitoring and the crop involved.

The How and Why of Blacklight Trapping

Blacklight traps are a useful tool in monitoring several economically-important, nocturnal insect pests including the European corn borer, armyworms, and cutworms, to name a few. The traps are useful in determining when the moths are flying as well as their relative abundance. This information will allow pest managers to determine the timing of peak periods of activity and subsequently, pest management activities. Although the use of blacklight traps has been proven beneficial for monitoring pest populations, these traps are not designed to reduce pest populations.

It is not necessary to locate a blacklight trap on every farm. Blacklight trapping is used primarily as a means of monitoring the development and relative activity of economically-important insect pests. Regional trapping information is useful and available in several printed and electronic newsletters disseminated by the WDATCP and UWEX.

Trap Location

If you choose to incorporate blacklight trapping as part of your pest monitoring program, it is important to properly locate the trap to assure an accurate representation of the insects you are monitoring. If monitoring European corn borers traps should be located in "action sites", grassy areas adjacent to corn fields where the adult corn borer moths congregate. The light should be placed 3-4 feet above the ground paying particular attention to positioning the light above the grassy vegetation. The traps should be no more than 300 feet from corn The further away from corn fields the traps are placed, the fewer number of moths that will be caught. However, trends in populations will not be affected by the distance from corn as long as the trap is located in the vicinity of corn fields. Blacklight trap location with respect to wind direction is not important as it is in the location of pheromone traps.

Care must be taken to locate traps away from other sources of light such as post lamps or heavily traveled roads. Typically, placing traps at least 200 feet from other light sources is sufficient. During full- and nearly full-moon phases, blacklight trap catches may be reduced because of the high amount of background light generated by the moon thereby reducing the contrast generated by the blacklight UV light.

When placing traps, you may wish to pay attention to potential vandalism. Blacklights, as well as 12 volt batteries, if used, are attractive to vandals.

Trap Efficiency

There are several variables that will affect moth catches in blacklight traps. Most common are inclement weather such as cold temperatures, high winds, and rain. The presence of any of these variables will reduce the number of moths caught. Keep in mind however, if weather conditions are prohibiting moths from being caught in light traps, those same weather conditions may also be having a negative impact on mating and egg-laying. Light traps often don't detect low densities of moths. Therefore it is important to keep in mind that even though no moths are being caught, there may still be active moths in the area.

Trap Monitoring

Blacklight traps should be checked frequently - preferably every other day. Fresh specimens are much easier to identify as many of the identifying characteristics become obscure with age. If possible, check and empty traps prior to rain since water may collect in the collection container and destroy the distinguishing characteristics on the wings. In general, moths smaller in size than the diamondback moth (wingspan < 5/8 inch) and larger than hawk moths (wingspan > 3 inches) are not economically important and can be ignored when sorting through a trap catch. The placement of a DDVP (dichlorvos) insecticide strip in the funnel portion of the collection container will kill the insects making them easier to identify.

To aid in moth identification, the UWEX IPM program has developed a color fact sheet entitled "Identifying Blacklight Trap Catches in the Upper Midwest". Single copies of this fact sheet is available free from the UW IPM program, (608) 262-6429. It illustrates each of the economically-important nocturnal moths and describes identifying characteristics.

Contents Pea (PE)

Verison 2.0 Printed 6/99

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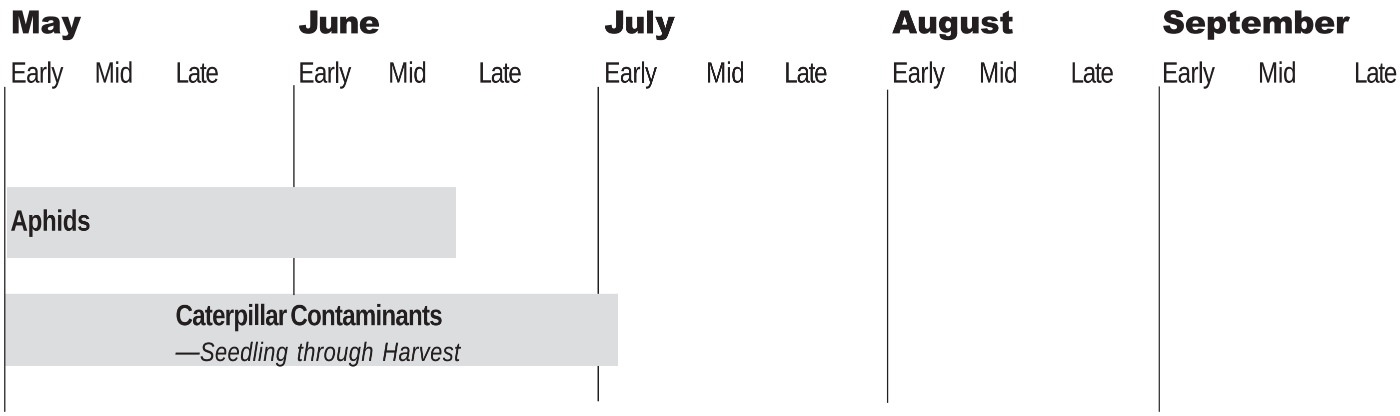
Scouting Calendars

Pea Insect Pests in Wisconsin



Pea Disease Scouting Table

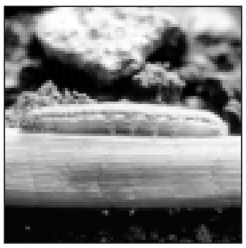
Diseases	Temperature	Climate	Occurrance
Aphanomyces Root Rot	72-82ºF	high soil moisture	pre-emergence—harvest
Downy Mildew	34-68ºF, 60ºF is best	high humidity, fog, heavy dew	
Fusarium Root Rot	72-82ºF		
Fusarium Wilt	75-82ºF	dry soil	seedling—harvest
Mosaic		weather that favors aphids	
Rhizoctonia Seedling Blight	soil temps =75-85ºF	high humidity and soil moisture	

Insect Contaminants of Peas

Common Names: Cabbage Looper, Alfalfa Looper, Celery Looper, Alfalfa Caterpillar, Imported Cabbageworm, Armyworm.

Scientific Names: *Trichoplusia ni*, *Autographa californica, Anagrapha falcifera, Plathypena scabra, Pieris papae, Pseudaletia unipunctata*, respectively.

Order: Lepidoptera



General Information

Biological Description

Cabbage Looper The cabbage looper adult is a grayish-brown night-flying moth with a wing span of 1.5". The mottled brown forewings are marked near the middle with a small silver-white figure-8 or letter-Y. Hind wings are uniformly brown. The caterpillar (larva), is called a looper because of the way it arches its body while moving. Mature larvae are up to 1 1/2 inches long, have a greenish body which tapers at the head end, with a thin white line along each side, two longitudinal white lines on the middle of the back, and three pair of prolegs at the distal end of the abdomen. Eggs are small, round and white in color and laid singly under the leaves near the edge. Pupae which are enclosed in a loosely woven silken covering are brown and 1/2-3/4 inches long.

Alfalfa Looper The alfalfa looper larvae may range from light to dark green in color. At maturity the larvae may reach 1 1/4 inches in length. As with the cabbage looper, it is characterized by the lack of prolegs on the middle abdominal segments and it's "looping" behavior while walking. Adult moths are silvery-grey with a darker fringe along the wing edges. A characteristic ivory funnel-shaped marking appears on the forewings. As with the cabbage looper, eggs are small, white and laid singly on the stems and leaves of host plants.

Celery Looper The celery looper adult has greyish-brown forewings with a patch of rust-colored scales outlined by silver. Larvae resemble that of the previous two pests in ranging from light to dark green. At maturity, larvae are 1 1/4 inches long.

Alfalfa Caterpillar The adult alfalfa cateripllar is a sulfur-yellow butterfly with distinct black markings along the margins of both the fore and hind-wings. Larvae are dark brown, becoming green once they begin to feed. A fine white line runs along the length of the body on each side. A faint red line may be seen within each white line. At maturity the larvae are 1 1/2 inches long.

Imported Cabbageworm The adult imported cabbage worm is a white butterfly with a 2 inch wingspan. Adult females have 2 black dots on each forewing while males are smaller with only 1 black dot and a black body. Bullet-shaped, yellow-orange eggs are laid on the leaves of host plants. Newly hatched larvae are yellow in color but become green once they begin to feed. Larvae have 5 pair of abdominal prolegs. The pupa is grey-brown with 2 angular projections at the head end.

Armyworm These sand-colored moths have a wing span of 1.5inches with definitive white dots in the center of each forewing and dark markings on the hind wings. The brownish-green larvae are hairless, have alternate dark and light stripes down their backs and are about 2 inches long when fully grown. The head is pale brown with dark markings. Pupae are dark brown and approximately 3/4 inch in length. They are sharply tapered at the tail end with a much more rounded head end. The greenish-white eggs are laid in rows or clusters on leaves.

Economic Importance

The six insects discussed in this profile typically do not pose a problem as it relates to yield in pea production for processing. However, contamination by any one of these insects poses a serious quality issue. Because of the increased costs associated with the screening and removal of the various insect contaminants, threshold levels for all of these pests are often set very low by the processors.

Life Cycle

Cabbage Looper Cabbage loopers probably do not overwinter in large numbers in Wisconsin, but migrate in from the south mid-July through September. Overwintering pupae give rise to the first generation adults in spring. White eggs are laid singly on the lower leaf surfaces in July. Larvae mature through 5 successively larger instars over the next 4-5 weeks before pupating. Adults emerge in 10-14 days, mate and lay eggs which give rise to the second generation. Second generation cabbage loopers cause damage in August and September.

Alfalfa Looper The alfalfa looper overwinters as an adult moth which emerges when temperatures warm to 40ºF in the spring. After mating, females lay from 500-1500 eggs on wild crucifers. The eggs hatch within a week and the first of five larval instars begins to feed. Each larval instar takes about three days to develop. Within approximately two weeks of egg hatch, pupation occurs. After one week, the next generation of adults emerges.

Celery Looper The celery looper overwinters as pupae in the soil. When springtime temperatures reach 50-55 degrees F, adult moths emerge and seek out host plants on which to lay their eggs. There are three generations per year.

Alfalfa Caterpillar The alfalfa caterpillar overwinters as pupae on alfalfa plants. In the spring, yellow butterflies emerge, mate and lay between 200 - 500 eggs singly on the lower leaf surface of alfalfa leaves. Alfalfa caterpillar larvae emerge as dark brown worms which become green soon after feeding begins. The larvae complete their development within two weeks of egg hatch at which time they enter the pupal stage without spinning a cocoon. There are two generations per year.

Imported Cabbageworm The imported cabbageworm overwinters as pupae. Adult butterflies emerge in late April or early May. The first generation eggs are laid on the leaves of cruciferous weeds. The eggs hatch in about one week, giving rise to the first instar larvae. After approximately 2 weeks, the larvae have completed development and pupate from which the second generation adults emerge one to two weeks later.

Armyworm It is not known how the armyworm overwinters in Wisconsin. The moths usually appear in late April and early May and mate. Eggs are laid in rows or clumps in the evening and at night. Leaf blades of grasses and small grains are often folded and sealed to protect the eggs. One week to 10 days after the eggs are laid, the larvae emerge and begin to feed. After feeding for 3-4 weeks, the full-grown larvae pupate for an additional two weeks and emerge as adults. There are three generation per season, with each generation lasting 5-6 weeks.

Host Range

The various lepidopterous insects which comprise the contaminants of processed peas exhibit a wide host range. Specific host plants for the loopers include all members of the cabbage family, mint, potatoes, lettuce, pea, spinach, parsley, tomato, beets and celery. The alfalfa caterpillar primarily feeds on alfalfa but may attack all members of the legume family. In addition to peas, all vegetables of the cabbage family serve as host to the imported cabbage worm. The fall armyworm will attack all plants in the grass family in addition to alfalfa, beans, potatos, spinach, tomato, cabbage, cucumber tobacco, and grain crops.

Environmental Factors

High humidity will increase the incidence of disease among populations of the insect pests previously described. This may be effective in holding down populations.

Damage/Symptoms

Larvae of each of the above lepidopterous insects pose a contamination threat to the processed crop. Direct damage to the plant is limited. However, refusal of the finished product by the processor may result in considerable economic loss as do sprays to control them.

Scouting Procedure and ET

Lepidopterous larvae are easily scouted by shaking plants to dislodge larvae onto a tray or drop sheet. Make counts in 10-20 foot sections of row scattered throughout the field. Thresholds have not been determined, but due to contamination problems are generally low. Each processor sets their own threshold limits and scouts should abide by the limits set. Total larval count of 2/foot of row during susceptible stages (flowering) will usually result in greater than 20% defoliation which may reduce yields.

Integrated Control

Non-Chemical Control

Natural Control: Natural controls are frequently quite effective in holding looper populations down. An egg parasite (trichogramma), several larval parasites and an egg-larval-pupal parasite (copidosoma) may become numerous. Several general predators attack the egg and larval stages.

There are also several natural enemies of the alfalfa caterpillar. The braconid wasps *Apanteles medicaginis* and *A. flaviconchae* are very effective in managing outbreaks of alfalfa caterpillars.

The braconid wasp *Apanteles glomeratus* and *Pteromalus puparum*, a chalcid wasp will reduce the numbers of imported cabbage worms.

In warm years, several tachinid flies and brachonid wasps effectively keep armyworms in check.

As populations of contaminant insects increases, several virus and fungal diseases may become epidemic. These virus and fungal parasites are particularly effective during cool, damp weather. However in spite of the numerous beneficial organisms, remedial control through insecticide treatment is required in years of heavy infestation.

Cultural Control: Spring plowing of debris and clean culture assist in reducing the potential for outbreaks.

Biological Control: There are no commercially available biological control agents which are cost effective to use to reduce the populations of various insect contaminants of processed peas.

Chemical Control

Commercial: Foliar insecticide applications are recommended for control of all insect contaminants of peas when threshold levels are reached. Chemicals labeled control include esfenvalerate and methomyl.

Insecticide Resistance: None.

References

W. S. Cranshaw and E. B. Radcliffe. (1984) Insect Contaminants of Minnesota Processed Peas. Technical Bulletin No. AD-TB-2211. 19 pp.

R. H. Davidson and W. F. Lyon (1987) Insect Pests 8th Ed. of Farm, Garden, and Home. John Wiley & Sons, New York 640 pp.

C. L. Metcalf and R. L. Metcalf (1993) Destructive and Useful Insects, their Habits and Control 5th Ed. McGraw-Hill Book Co., New York 1087 pp.

Insects of Peas. A Pacific Northwest Cooperative Extension Publication. (1974) No. 150. 19 pp.

Armyworm

Scientific Name: *Pseudaletia unipunctata* (How.)
Order: Lepidoptera
Family: Noctuidae.

General Information

Biological Description

The armyworm is generally not a problem on vegetable crops; it prefers grasses and grains. However, grass weeds in pea fields will attract moths. Larvae present on these grasses are a potential contaminant of the processed peas when they are harvested. Outbreaks are more common following cold, wet, spring weather. The sand-colored moths have a wing span of 1.5" with definitive white dots in the center of each forewing and dark markings on the hind wings. The brownish-green larvae are hairless, have alternate dark and light stripes down their backs and are about 2" long when fully grown. The head is pale brown with dark markings. Pupae are dark brown and approximately 3/4 inch in length. They are sharply tapered at the tail end with a much more rounded head end. The greenish white eggs are laid in rows or clusters on leaves. Moths often seem to congregate in certain locations. Armyworms often are confused with the variegated cutworm and other related species.

Economic Importance

Damage is sporadic and dependent on heavy flights of southern moths reaching Wisconsin. The major concern results from contamination of the pea pack with armyworm body parts.

Life Cycle

It is not known if the armyworm overwinters in Wisconsin. The moths usually appear in late April and early May and mate. Most of the early season moths are immigrants from southern states. Eggs are laid in the evening and at night and eggs are laid in rows or clumps of many eggs. Leaf blades of grasses and small grains are often folded and sealed to protect the eggs. One week to 10 days after the eggs are laid, the larvae emerge and begin to feed. After feeding for 3-4 weeks, the full-grown larvae pupate for an additional 2 weeks and emerge as adults. There are 3 generations per season, with each generation lasting 5-6 weeks. The second larval generation which appears in July is the largest and most damaging generation to Wisconsin crops. The fall generation is typically not injurious and is often heavily parasitized by beneficial insects, fungus and virus.

Host Range

Armyworms attack all grasses, particularly wheat, oats, corn barley and rye and some legumes; but under stress will attack neighboring vegetable crops and seedling alfalfa. Additionally, the presence of grass weeds in the peas will attract moths for egg laying.

Environmental Factors

Cold, wet spring weather precipitates armyworm outbreaks.

Damage/Symptoms

Larvae tend to feed at night or on cloudy days and hide in the soil or under foliage during the day. On older plants they may eat moderate amounts of foliage with young larvae concentrating on terminal growth while older larvae feed near the ground. Armyworms appear later in the season than the black cutworm and, as a result, seldom damage pea seedlings. Damage is usually highest along the field edge or in grassy spots. Cutworms and armyworms pose a serious contamination problem in peas mechanically harvested for canning. Even head capsules from the larvae can contaminate the processed peas.

Scouting Procedure and ET

Timely detection is critical if post-emergent insecticidal treatment is to be effective. When feeding damage is observed, shake 5-foot sections of 2 adjacent rows and count larvae on soil surface. Repeat in several locations since infestations may be restricted to certain areas. Damage usually begins along field edges and moves inward as the insects migrate.

Integrated Control

Non-Chemical Control

Natural Control: A number of braconid wasps and tachinid flies help keep armyworm numbers down, as do birds, toads, skunks and some domestic fowl. Armyworms are only problematic in grassy areas.

Cultural Control: Since female moths prefer to lay eggs in grassy areas, keeping grassy weeds controlled will lessen the possibility of problems. Avoid planting susceptible crops in low wet areas or in rotations following sod. If this is unavoidable, be sure to plow in the fall of the previous season to decrease early spring egg-laying sites. Killing grass with a herbicide or tillage may drive armyworms to the susceptible vegetables.

Biological Control: Several natural enemies exist which may keep armyworm populations low. The red-tailed tachinid fly (*Winthemia quadripustulata*) is one such biocontrol agent. It lays its eggs on the armyworm's back and the tachinid larvae bore into larval armyworms to feed. In addition, several ground beetles and parasitic hymenoptera prey upon the armyworm. There is also and egg parasite (*Telenomus minimus*) that is effective in preventing egg hatch and subsequent larval feeding damage.

Chemical Control

Commercial: Carbaryl, esfenvalerate, and methomyl are foliar treatments which are labeled for the control of armyworms.

Homeowner: Apply carbaryl bait if extensive foliage feeding observed.

Insecticide Resistance: None.

References

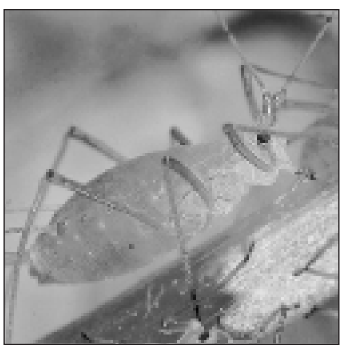
R. H. Davidson and W. F. Lyon (1987) Insect Pests 8th Ed. of Farm, Garden, and Home. John Wiley & Sons, New York 640 pp.

C. L. Metcalf and R L. Metcalf (1993) destructive and Useful Insects, their Habits and Control 5th Ed. McGraw-Hill Book Co., New York 1087pp.

Pea Aphid

Scientific Name: *Acyrthosiphon pisum*

Order: Homoptera



General Information

Biological Description

The pea aphid is a small, green aphid approximately 1/4 inch long and one-third as wide. Nymphs resemble adults except for their smaller size and lack of wings. Eyes are red and their legs and cornicles may be tipped with yellow.

Economic Importance

The pea aphid is the most damaging insect pest of peas in Wisconsin.

Life Cycle

The pea aphid overwinters as eggs on plant tissue of alfalfa, clover, leguminous weeds and other leguminous plants. The following spring, the eggs hatch into wingless females which give rise to the next generation of aphids without engaging in sexual reproduction. Ten to fourteen young nymphs per female per day is common. The nymphs undergo 4 molts before reaching the adult stage. Twelve days after birth, the nymphs are reproductively mature. In late May or June, winged adults migrate into pea fields from the alfalfa and other legumes, clover and other leguminous crop fields which provided a habitat up to this point. As the season progresses and peas no longer provide adequate food supplies for aphid populations, winged forms again appear and migrate back to alfalfa. Late in the season, as cooler temperatures and shorter daylengths are prevalent, male aphids are produced and sexual reproduction occurs. Black eggs are laid on the stems and leaves of plants for overwintering. Alfalfa and clover fields are the most common source of pea aphids that invade pea fields.

Host Range

Peas, sweet peas, clover, alfalfa and leguminous weeds.

Environmental Factors

Heavy rains and cool temperatures may slow the increase of aphid populations.

Damage/Symptoms

Feeding injury caused by the pea aphid results when the aphid ruptures cells in the leaves, stems, blossoms and pods of the plant in an effort to remove plant sap. Wilting, stunting and chlorosis are commonly associated with aphid feeding particularity when populations are high. Aphids can kill pea plants when population densities are high. In addition to the direct injury caused by feeding activity, the pea aphid is a vector of several virus diseases of peas (see Pea Diseases - Viruses elsewhere in this program). Aphids excrete a sticky substance called honeydew. Sooty molds or other fungi which grown on honeydew-covered plant parts may lead to harvest-ing problems and also make the foliage inedible.

Scouting Procedure and ET

Pea fields should be monitored for aphids using a sweep net. Typically, when more than 35 aphids per sweep, or 2 aphids per plant are present, and the peas are more than ten days from harvest, insecticide treatment is recommended.

Integrated Control

Non-Chemical Control

Natural Control: There are numerous predators and parasites of the pea aphid. Some of the more important natural enemies include syrphid flies, braconid wasps, lady beetles and lacewings. In addition, fungal pathogens are also effective in reducing aphid populations.

Cultural Control: The pea varieties Pride, Yellow Admiral and Onward have been shown to be somewhat resistant to pea aphid attack.

Biological Control: None.

Chemical Control

Commercial: Foliar applications of esfenvalerate, dimethoate, methomyl and encapsulated methyl parathion are recommended for aphid control once populations reach threshold levels.

Homeowner: Insecticidal soaps or strong sprays of water may effectively control aphid populations.

Insecticide Resistance: None.

References

Davidson, R. H. and W. F. Lyon. Insect Pests of Farm, Garden, and Orchard, 8th ed. John Wiley & Sons, New York. 1987. 640pp.

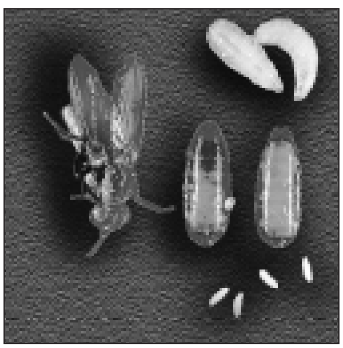
Metcalf, R. L. and R. A. Metcalf. Destructive and Useful Insects, Their Habits and Control, 5th ed. 1993. McGraw-Hill, New York.

Seed Corn Maggot

Scientific Name: *Hylemya platura*

Order: Diptera

Family: Anthomyiidae



General Information

Biological Description

The yellowish white larvae are typical fly maggots, 1/5 inch long when fully grown, cream colored, legless and wedge-shaped with the head end sharply pointed. Pupae are brown, 1/5 inch long, cylindrical in shape, and rounded on both ends. Adults resemble miniature houseflies; they are dark grey, 1/5 inch long and their wings are held overlapped over their bodies while at rest. Flies are smaller than cabbage and onion maggots, with whom they are easily confused. Eggs are about 1/32 of an inch in length, oval, and white.

Economic Importance

This insect can reduce the successful germination of peas in Wisconsin.

Life Cycle

The seedcorn maggot overwinters as pupae in the soil. Peak adult emergence from overwintering pupae occurs anytime from early to mid-May when degree day accumulations have reached 200 DD_{39}. Newly emerged adults may be seen flying in large numbers over recently-tilled fields. Adults mate within 2-3 days of emergence and females lay eggs in soils containing high organic matter or near seeds and seedlings of a wide variety of plants. Egg hatch occurs in 2-4 days. Larval feeding, development, and pupation all occur below ground and the subsequent generation of adults appears 3-4 weeks later. This sequence of events is repeated and 3-5 generations of seedcorn maggots may occur during a season.

Host Range

Seeds and seedlings of most vegetable crops including beets, cabbage, corn, cucumbers, peas, radishes, squash, turnips, and kidney, lima and snap beans.

Environmental Factors

Cool, wet weather favors this insect while hot, dry weather is detrimental to its survival. Therefore, the seedcorn maggot is more likely to be a problem during the spring and early summer than later in the season. Cool, wet springs and doughty conditions may delay seed germination and lead to increased damaged by the seedcorn maggot. The application of livestock manure and incorporation of vegetation prior to egg laying makes fields more attractive to the female flies. Tillage of live plant material is more attractive than tillage of dead plant residue. The decomposition of the green vegetation may produce compounds that attract the flies.

Damage/Symptoms

Larval seed corn maggots can destroy germinating seed thereby preventing successful germination.
Emerged plants may be severely weakened by the feeding activity of the seed corn maggot.

Scouting Procedure and ET

Seedcorn maggot damage cannot be detected until it is too late to take control actions. Therefore, economic thresholds for this insect are not useful and insecticides are applied at planting as a protective measure. However, if you notice wilted, yellowed or stunted plants, or seedlings with pinholes in the leaves check for seedcorn maggots. If numbers justify, check 50 plants in five separate field areas. To monitor adult populations, place pans filled with soapy water along the field edge at 100 ft intervals. Flies trapped in the water should be removed every 4-6 days at which time fresh soapy water should be added. Records of the number of flies trapped will indicate when fly numbers are building up or tapering off.

Forecasting the appearance of generations may be accomplished by accumulating degree days beginning when the ground thaws in the spring. Degree days are calculated each day using the formula ((maximum temperature + minimum temperature)/2)-39. A running total of degree days is kept and peak emergence of the first three generations will occur when totals of 200, 600 and 1000 degree days, respectively, have been reached.

Integrated Control

Non-Chemical Control

Natural Control: Naturally occurring fungal diseases occasionally will reduce seedcorn maggot numbers significantly, particularly when flies are abundant and relative humidity is high. During a fungal epidemic, dead or diseased flies can be seen clinging to the highest parts of plants along field edges. Predaceous ground beetles, which eat seedcorn maggot eggs, larvae, and pupae can also be important in reducing maggot numbers. Because these soil-inhabiting beetles are susceptible to insecticides, broadcast soil insecticide treatments should be avoided whenever possible.

Cultural Control: Since the seed corn maggot is attracted to decaying organic matter, fields where animal or green manure has recently been applied should not be planted. Plant seeds as shallow as feasible to speed germination. Any procedure which promotes fast germination and seedling growth will reduce chances of maggot infestation. In addition, home gardeners may soak seeds in water for about 2 hours prior to planting to promote fast germination and seedling growth. It is also possible to avoid seedcorn maggot damage by planting during fly-free periods that occur between generations of flies (see Scouting/ET).

Biological Control: None.

Chemical Control

Commercial: Diazinon is labeled as a seed treatment for control of seedcorn maggots. Planter box seed treatments containing diazinon can be mixed with the seed immediately before planting to control seed maggot. Refer to the product label for more information on specific application instructions and precautions.

Insecticide Resistance: None.

References

R. H. Davidson and W. F. Lyon (1979) Insect Pests 7th Ed. of Farm, Garden, and Home. John Wiley & Sons, New York 596 pp.

C. L. Metcalf and R. L. Metcalf (1993) Destructive and Useful Insects, Their Habits and Control 5th Ed. McGraw-Hill Book Co., New York .

Aphanomyces Root Rot

Cause: *Aphanomyces euteiches* f. sp. *pisi*
Type: Fungus

General Information

Biological Description

Aphanomyces euteiches f. sp. *pisi* is the fungus responsible for causing common root rot in peas. *Aphanomyces* belongs to the group of fungi classified as water molds. As with the causal organism of common root rot in beans, this fungus produces both sexual oospores and motile, asexual zoospores.

Economic Importance

Aphanomyces root rot is the most important pea disease in the Midwest. Annual yield losses of 10% have been observed and in some fields, 100% loss may be realized. Aphanomyces occurs in fields, or portions of fields where soil moisture is high. When plants are infected early in the growing season, entire fields may be made worthless. The disease not only destroys individual vines, but also reduces the quality of shelled peas by making them irregular in size, variable in harvesting maturity, and lacking in sugar content. The use of cultural practices that prevent the buildup of inoculum helps to control this root rot.

Disease Cycle

Aphanomyces root rot is a soil-borne fungus which is capable of infecting pea plants at all stages of growth. The disease overwinters as thick-walled oospores in plant debris. Asexual, motile zoospores are borne on thread-like sporangia. These spores are disseminated by movement through soil water or, more commonly, infested equipment. The pathogen may also move through a stand by plant-to-plant contact. Zoospores are capable of swimming in soil, water for up to five days before their viability is lost. Aphanomyces inoculum builds up rapidly in the soil but decreases very slowly despite a rotation out of peas. Fields infested with Aphanomyces may remain unsuitable for planting susceptible crops for up to 10 years.

Host Range:

Aphanomyces root rot attacks pea, alfalfa, sweet clover, snapbean, cowpea, sweet pea, spring vetch, and other species of Lathyrus and Vicia. Soybeans do not serve as a host of this disease.

Environmental Factors

Aphanomyces produces such a large number of spores that it can be readily disseminated over large areas through running or splashing water and in contaminated soil carried from one field to another by farm implements and machinery. The fungus is able to survive in the soil for up to 10 years. Warm temperatures (72-82^{o}F) favor disease development, even though infection may occur at cool to moderate temperatures.

High soil moisture is also conducive to infection and disease development. As little as 24 hours of soil saturation is necessary for extensive infection to occur. Saturated soils accelerate the spread of disease, but not necessarily the rate of infection. Warm temperatures associated with moisture stress increase disease development and symptom expression, particularly when preceded by a cool, wet spring.

Symptoms

Aphanomyces root rot infects peas of all ages. Infection usually occurs at the time of crop emergence. Early infection develops as long, soft, water-soaked areas on the surface of the lower stem and root. Symptoms first appear two weeks after infection. As the disease progresses, these discolored areas become light tan and spread over the entire root system. The root system may become slimy and dark as the disease develops, especially if the soil remains wet for long periods. Because the disease kills branch roots, the upper taproot separates easily from the rest of the root system, which remains in the soil if the plant is pulled up. Plants that are infected while very young are stunted and weakened. Pods may have only one or two peas and these are inclined to be large and irregularly shaped. Peas of this type are usually poor in quality. In severe cases, plants wilt, turn yellow, shrivel and die prematurely. Plants infected late in the season show almost no above ground symptoms and many of them grow and fruit normally.

Scouting Procedure/ET

Prior to planting peas, a soil sample should be collected and submitted for testing to determine the level of inoculum present. Soil sampling should be done in the fall prior to planting. One gallon of soil should be obtained from multiple sites over a “W” pattern through the entire field. A sampling depth of 6 inches is recommended. Samples should be submitted to the UW-Madison Department of Plant Pathology to determine the disease index. Disease indices which range between 0-50 are safe for planting peas. Indices falling within 51-69 are considered questionable while those fields rated as 70-100 should be avoided if possible. Fields which rate in the questionable range should not be planted to peas whenever possible.

Integrated Control

Non-Chemical Control

Cultural: Most infection occurs during germination. A well-drained soil is beneficial in reducing the amount of infection, particularly during wet years. Plant seeds treated with a fungicide in a well-drained, friable soil. Practice a 3 year or longer crop rotation which excludes peas, alfalfa, beans, sweet clover, cowpea, and vetch.

Good fertilization practices will improve the vigor of the crop thereby increasing its ability to withstand disease.

The best method to prevent losses due to Aphanomyces is to determine the inoculum potential of a field prior to planting. A method for determining a field's potential for root rot development has been developed by UW-Madison specialists. Soil samples are assayed for root rot potential and based on the results of this test, recommendations are made on whether the field can be safely planted to peas are made. Details of this method are available upon request from the Plant Pathology Dept., UW-Madison.

There is good evidence that soil treatment trifluralin herbicide for weed control provides some protection against Aphanomyces root rot.

Resistant Varieties: Considerable research has been done to develop pea varieties which are resistant to Aphanomyces. At the present time, there are no disease resistant cultivars available. Thousands of pea lines representing germplasm collections throughout the world have been tested for resistance to pea root rot. Lines with some tolerance have been identified, but it will take several years before this tolerance is transferred into commercially acceptable plant types. Meanwhile screening and breeding efforts continue.

Chemical

Seed treatment with Captan may be effective in reducing the likelihood of infection. Once infection has occurred, chemical fungicide treatments are not economical or practical to use.

Fungicide Resistance: None.

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Compendium of Pea Diseases. 1984. American Phytopathological Society. St. Paul, MN. 57pp.

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Hagedorn D. J. 1976. Handbook of pea diseases. University of Wisconsin Extension Service Publication A1167. 41 pp.

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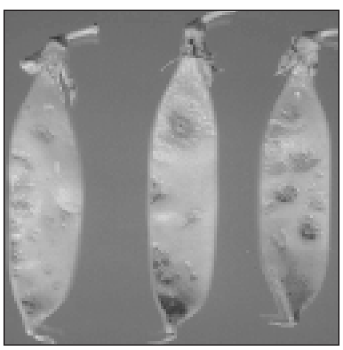
Zaumeyer W. J. 1962. Pea diseases. USDA Agriculture Handbook No. 278. 30 pp.

Downy Mildew

Cause: *Peronospora pisi*
Type: Fungus



General Information

Biological Description

Peronospora pisi belongs to the group of fungi known as oomycetes. The oospores which result from the mating of the antheridia and oogonia are light brown to yellow and round.

Economic Importance

Downy mildew is a common and troublesome pea disease where peas are grown under cool, moist conditions. In most of the pea-growing areas of the United States the disease is present during the early part of the growing season and is seldom of economic importance.

Disease Cycle

The fungus overwinters in pea straw and as oospores mixed with seed and soil. Spores are produced on infected plants and are moved to other plants or fields by splashing or running water, wind or equipment. Symptom expression occurs 6-19 days after plant infection. Asexual sporangia continue to infect healthy plants throughout the season. Sexual oospores are thick-walled spores that can remain viable in the soil for many years.

Host Range

The fungus which causes downy mildew on peas appears to be restricted to this crop's roots.

Environmental Factors

Downy mildew development is favored by cool, moist weather. The disease appears in the areas where the night temperatures are relatively low and fogs or heavy dew is prevalent. Infection may occur after only 4 hours of leaf wetting, provided the temperature for spore germination is ideal. Infection may also occur when the relative humidity is 90% without the presence of free water. Temperatures between 34-68 degrees F, with 60 degrees F being ideal.

Symptoms

The symptoms of downy mildew first appear on the lower leaf surface as fluffy, white to grey patches of the fungus. These patches often turn darker with age. On the upper side of the foliage there are yellow to brown areas with indistinct margins. If the growing point of the plant becomes systemically infected, the upper portion of the plant may become distorted and significantly stunted.

Such plants may become chlorotic. The disease may appear on the pods without foliar infection. Young pods are particularly susceptible. Several yellow-brown diseased areas of indefinite size and shape are apparent in pod infections. These irregular blotches may be slightly sunken. On the inside of the pod, opposite the outer diseased area, there may be a white, felt-like growth of the pod endocarp. Peas developing near these areas remain small and may have brown, sunken spots.

Scouting Procedure/ET

There are no monitoring practices recommended for downy mildew. While monitoring fields for other diseases and insect pests, note whether there is evidence of downy mildew.

Integrated Control

Non-Chemical Control

Cultural Control: Downy mildew can be controlled through crop rotation, used of disease-free seed, and resistant varieties. A rotation of at least 3 years is necessary to reduce the potential for infection.

Resistant Varieties: The following varieties are resistant to downy mildew: Dark-skin Perfection, Greenland, Green Arrow, and Onward.

Chemical Control

Metalaxyl (Apron) seed treaments may be made to provide systemic control of downy mildew.

Fungicide Resistance: None.

References

Compendium of Pea Diseases. 1984. American Phytopathological Society. St. Paul, MN. 57pp.

Hagedorn, D. J. 1974. Virus diseases of pea, Pisum sativum. Monograph No. 9, The American Phytopathological Society. St. Paul, Minnesota. 47pp.

Hagedorn, D. J. 1976. Handbook of pea diseases. University of Wisconsin Cooperative Extension Publication A1167. 41pp.

Sherf A. J. and A. A. MacNab. 1986. Vegetable diseases and their control. John Wiley & Sons, New York. 728pp.

Fusarium Root Rot

Cause: *Fusarium solani* f. *pisi*
Type: Fungus

General Information

Biological Description

Fusarium solani f. *pisi* is an ascomycete fungus. It produces curved, transparent macroconidia with three septations and chlamydospores or resting spores. Microconidia are rare in nature.

Economic Importance

Fusarium root rot occurs as a troublesome and sometimes important pea disease in almost all of the pea-producing areas of the United States. In the Midwest, fusarium root rot may occur on plants which are also suffering from near-wilt caused by *Fusarium oxysporum* and/or Aphanomyces root rot.

Disease Cycle

Fusarium can live indefinitely as resting chlamydospores in the soil. It grows and produces spores on dead stems and roots of plants. The brown spores are splashed and disseminated by any means that move soil from one field to another. Infection occurs through stomates or the epicotyl or hypocotyl. Under adverse conditions, chlamydospores are produced.

Host Range

Fusarium solani f. *pisi* only affects peas.

Environmental Factors

Development of fusarium is favored by relatively high soil temperatures (75-82 degrees F). Soil moisture has little influence on disease development as long as sufficient moisture is available for adequate plant growth.

Symptoms

The initial symptoms often appear near the area of cotyledon attachment and consist of slender, light brown lesions along the taproot and on the side roots. These lesions enlarge and coalesce until the main roots become brown and shrunken. The discoloration and shrinking progresses upward to 1-2 inches above the soil line. The vascular tissue of infected plants exhibits a brick red discoloration which extends upward one to three nodes above the soil line. Diseased plants appear unthrifty and dwarfed to varying degrees depending upon the severity of infection, and may wilt or die prior to pod set.

Scouting Procedure/ET

There are no formal monitoring procedures recommended for fusarium root rot. Examination of plants for early symptoms should be made during routine insect monitoring visits.

Integrated Control

Non-Chemical Control

Cultural Control: Early planting and the use of an early-maturing cultivar will reduce the chance of infection.
Rotate crops on a 4 year rotation to prevent inoculum build-up in the soil.

Resistant Varieties: The use of resistant or tolerant varieties is the best means of managing this disease. There are currently no known commercial pea cultivars which are a high level of resistance to fusarium root rot. However, some lines exhibit tolerance to the disease. Some of the tolerant varieties are Bolero, Bounty, Daybreak, Dual, Early Frosty, Extra Early Little Marvel, Frosty, Green Arrow, Knight, Little Marvel, Mammoth Melting Sugar, Novella II, Petit Pois Giroy, Progress No. 9, Sparkle, Spring, and Utrillo.

Chemical Control

None.

Fungicide Resistance: None.

References

Compendium of Pea Diseases. 1984. American Phytopathological Society. St. Paul, MN. 57pp.

Hagedorn, D. J. 1974. Virus diseases of pea, Pisum sativum. Monograph No. 9, The American Phytopathological Society. St. Paul, Minnesota. 47pp.

Hagedorn, D. J. 1976. Handbook of pea diseases. University of Wisconsin Cooperative Extension Publication A1167. 41pp.

Sherf A. J. and A. A. MacNab. 1986. Vegetable diseases and their control. John Wiley & Sons, New York. 728pp.

Fusarium Wilt

Cause: *Fusarium oxysporum* f. sp. *pisi*
Type: Fungus

General Information

Biological Description

Fusarium wilt is a destructive disease of peas. It was a serious problem on peas and more widespread in the Midwest in the 1960's. The disease attacks plants of all ages and reduces yields by killing the plants before they completely mature. There are currently six races of Fusarium which are capable of causing wilt symptoms in peas. Races 2 and 5 have been associated with the symptoms of near-wilt.

Economic Importance

Fusarium wilt is less of a problem today than it was in the 1960's as a result of the widespread use of resistant varieties of peas commonly planted in commercial fields.

Disease Cycle

Fusarium oxysporum f. sp. *pisi* overwinters as resting chlamydospores in the upper soil layers. In the spring, the fungus invades the root system of developing pea plants. Disease dissemination occurs via the movement of contaminated soil or plant debris or infected seed.

Host Range

This fungus causes severe injury only on peas. It can also infect species of vetch.

Environmental Factors

The fungus can live indefinitely in the soil. It may be carried on seed to other fields. The mycelium or spores that are produced on dead plant tissue are also spread by any means that moves soil. The fungus does not appear to be sensitive to soil moisture levels or alkalinity, although the incidence of wilt is slightly greater where the soil is moderate in moisture content. In very dry soil, the infected plants suffer the greatest injury. In very wet soil, infection is almost non-existent. When the soil is neutral or alkaline, there is more injury than in acid soils. The disease is favored by temperatures of 75-82^{0}F and soil temperatures greater than 68^{o}F result in rapid spread of the disease.

Symptoms

Plants can become infected at any stage of development from the youngest seedlings to mature vines. The first signs of the disease are pale leaflets and downward curling of stipules and leaflets. There is often a thickening of the basal internode with an associated brittle stem. Growth of the plant is checked. The upper part of the plant may become more rigid than normal. The leaves wilt, beginning with the lower leaves and progressing upward. The entire plant eventually wilts, and the stem shrivels. The underground portion of the stem is often larger than normal. Pod formation is usually limited, and seeds rarely develop in flattened pods. Few rootlets are injured, and a cursory examination of the root system yields essentially normal roots. However, when dissected longitudinally, a light yellow to orange-brown discoloration of the vascular system appears in the upper taproot which extends up the stem. Vascular discoloration is often more pronounced in Race 2 of the fungus. Root symptoms appear following foliage symptom expression. Infection initially appears to be localized within the field in the case of Fusarium wilt caused by Race 2. Near-wilt generally affects 1/2 of the plant and conversely, appears to be scattered throughout the field.

Scouting Procedure/ET

There are no monitoring practices recommended because there is no control for fusarium wilt once it has begun. Proper identification of suspected symptomatic plants is recommended so planning for future plantings in infested fields may be done. There are no soil assays to determine the level of inoculum.

Integrated Control

Non-Chemical Control

Cultural: Long rotations help reduce soil-borne populations. Peas can be grown successfully on rotations of 5-6 years. Early planting in infested fields may reduce disease severity by avoiding optimal soil temperatures for disease development.

Resistant Varieties: Fusarium wilt can be effectively and economically controlled by growing resistant varieties. Most pea varieties are wilt-resistant. A few of the resistant pea varieties include Ace, Alaska Sweet, Bolero, Bounty, Dark Seed Perfection, Daybreak, Dot, Dual, Early Freezer, Early Frosty, Eureka, Freesonian, Galaxie, Green Galaxie, Green Arrow, Hardy, Knight, Lincoln, Little Marvel WR, Mamoth Melting Sugar, Midway, Novella, Novella II, Petie Pois Giroy, Ranger, Resistant Early Perfection, Resistant Thomas Laxton, Saturn, Signet, Skagit, Small Sieve Freezer, Sparkle, Spring, Sprite, Thomas Laxton, Utrillo, Venus, and Viking.

Chemical Control

There are no fungicides registered for control of fusarium wilt. Soil fumigation helps to reduce soil borne inoculum.

Fungicide Resistance: None.

References

Compendium of Pea Diseases. 1984. American Phytopathological Society. St. Paul, MN. 57pp.

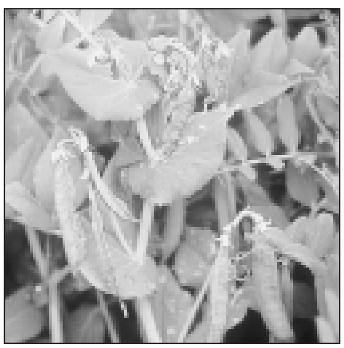
Sherf A. J. and A. A. MacNab. 1986. Vegetable diseases and their control. John Wiley & Sons, New York. 728pp.

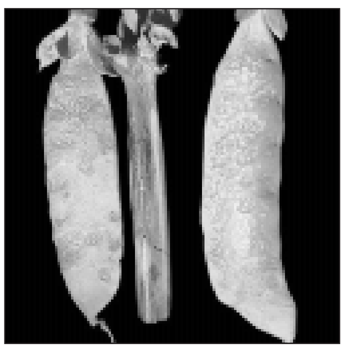
Zaumeyer, W. J. 1962. Pea diseases. Ag Handbook No. 228. 30pp.

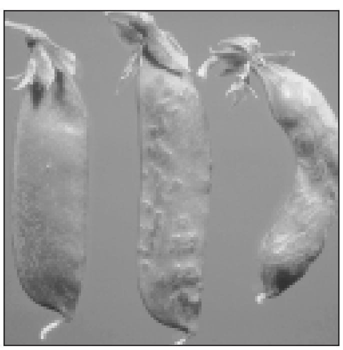
Mosaic

Cause: Bean Mosaic Virus,
Enation Mosaic, & Other
Virus Complexes

Type: Virus







General Information

Biological Description

A number of distinct viruses have been reported in peas. In Wisconsin, the most common pea viruses are bean yellow mosaic virus, pea enation virus and red clover vein mosaic virus. Identification of individual viruses may be made through gel immunodiffusion, ELISA, and immunoabsorbant electron microscopy.

Economic Importance

Virus disease outbreaks in peas can result in economic loss, but this is usually not the case. Enation mosaic virus may be the most important virus disease in the United States.

Disease Cycle

The pea mosaic viruses survive between crops in weeds and ornamental plants. In the spring, pea and potato aphids (*Acyrthosiphon pisum* & *Macrosiphon euphorbiae*) acquire the viruses as they feed on these infected plants. As the winged aphids migrate, the viruses are spread to peas. The virus can be transmitted by the aphid for up to eight days after initial acquisition. Symptom expression usually occurs 10-13 days following inoculation. In years with mild winters, aphids can survive in larger numbers and the likelihood of virus infection is increased. Most pea viruses are not transmitted through seed. An exception to this is the pea seed-borne mosaic virus.

Host Range

<u>Bean yellow mosaic virus</u> has a rather wide host range. Those plants which are hosts include lespedeza, white, blue, and yellow lupine, white sweet clover, black tepary bean, mung bean, broad bean, soybean, crimson clover, spring vetch, alsike clover, button medic, field pea, hairy vetch, monantha vetch, purple vetch, red clover, rough peavine, yellow sweet clover subterranean clover, cowpea, garbanzo bean, and gladiolus.

<u>Pea enation virus</u> infects pea, soybean, broad bean, sweet pea, yellow sweet clover, crimson clover, alfalfa, common vetch, hairy vetch, alsike clover, white sweet clover, milk vetch, chickpea, flat pod pea vine, white and blue lupine, cluster clover, persion clover, subterranean clover, woolypod vetch, hungarian vetch, button medic, and globe amaranth.

<u>Red clover vein mosaic virus</u> infects pea, white and yellow sweet clover, field pea, alsike clover, crimson clover, red clover, showy vetch, spring vetch, blue lupine, purple vetch, monantha vetch, sweet pea, white clover and broad bean.

Environmental Factors

Mild winters tend to favor the survival of aphids, the vector of many virus diseases. Warmer temperatures and lack of severe thunderstorms during the spring encourage aphid multiplication, resulting in increased virus transmission. Temperatures below 60°F or above 86°F cause the symptoms of virus infection to be masked. The optimum temperatures for normal symptom expression are between 70-80°F.

Symptoms

Viruses cause a variety of symptoms on peas. The most obvious symptom of bean yellow mosaic on pea is the yellow mottling of the leaves and stipules between the veins. Patches of normal green tissue of various sizes are scattered irregularly over the surfaces of both leaves and stipules. Veins sometimes clear. Plants become stunted if they are infected when young. The upper leaves and stipules become wrinkled and twisted or otherwise malformed. Pods may be fewer and smaller than normal. Severity of symptoms depends on the pea cultivar and the environment. Pea enation mosaic causes blister-like outgrowths from the lower leaf surface and pods. Scattered chlorotic areas may be apparent on the foliage. As the chlorosis progresses, a translucent 'window' may appear. Infected pods are severely deformed. Infections caused by red clover vein mosaic virus result in extremely stunted plants with veins cleared and a proliferation of axillary buds. Several viruses may infect peas at the same time and cause pea streak. Red clover vein mosaic plus bean yellow mosaic often cause this disease. The most conspicuous symptom is the brown to purple streaks that develop on pea stems. Barren pods may develop brown or purple spots.

Scouting Procedure/ET

A rigorous scouting program which includes monitoring aphid populations is useful in determining when aphid populations have reached injurious levels. It is also beneficial to monitor aphid populations in nearby fields, especially small grains and alfalfa and in weedy borders which surround pea fields.

Integrated Control

Non-Chemical Control

Cultural: Practice effective aphid control. Eliminate weed and ornamental hosts, especially gladiolus and other perennials from areas in and near the field. Periodic mowing of weeds which surround pea fields will reduce the amount of favorable aphid habitats. Perennial hosts provide a means for the virus to overwinter. Aphids can then transmit the virus from these perennials to peas early in the season. Early infection causes the greatest losses.

Resistant Varieties: Many pea varieties are resistant to bean yellow mosaic virus. These include Horal, Perfection, Bonneville, Canner King, Delwiche Commando, Early Snap, Green Arrow, Improved Penin, Knight, Loyalty, Maestro, Merit, Pride, Resistant Famous, Wasatch, Wisconsin Early Sweet, Wisconsin Perfection, Early Perfectah, Bridger, Cadet, Conner Prince, Early Perfection 109, Early Perfection 174, Ensign, Midway, Mohawk, New Era, New Season, New Wales, NWR Hyalite, Sparkle, Thriftigreen, and Wisconsin C165. No commercial pea varieties are available that are resistant to red clover vein mosaic virus. The varieties Aurora, Cascadia, Knight, Midway, Oregon Giant, Oregon Sugar Pod II, and Perfected Freezer are resistant to pea enation mosaic virus.

Chemical Control

There is no effective chemical control for controlling virus diseases in peas. However, systemic insecticides used to manage aphid populations may reduce the incidence and spread of disease.

Fungicide Resistance: None.

References

Compendium of Pea Diseases. 1984. American Phytopathological Society. St. Paul, MN. 57pp.

Hagedorn, D. J. 1974. Virus diseases of pea, Pisum sativum. Monograph No. 9, The American Phytopathological Society. St. Paul, Minnesota. 47pp.

Hagedorn, D. J. 1976. Handbook of pea diseases. University of Wisconsin Cooperative Extension Publication A1167. 41pp.

Sherf A. J. and A. A. MacNab. 1986. Vegetable diseases and their control. John Wiley & Sons, New York. 728pp.

Zaumeyer, W. J. 1962. Pea diseases. Ag Handbook No. 228. 30 pp.

Rhizoctonia Seedling Blight

Other Common Name: Rhizoctonia Tip Blight
Cause: *Rhizoctonia solani*
Type: Fungus

General Information

Biological Description

The imperfect fungus which causes Rhizoctonia seedling blight is light-colored and transparent initially but darkens with age. As with other species of Rhizoctonia, the hyphae possess the characteristic right-angle branches with a septum located near the branch.

Economic Importance

Rhizoctonia seedling blight occurs only occasionally on peas and is generally of minor importance. However, it has occasional economic significance in the Midwest.

Disease Cycle

The rhizoctonia fungus can live indefinitely in the soil. It is disseminated by any means which moves infested soil from one area to another. Long distance transport typically occurs through the movement of mycelium on infested plants or sclerotia in soil. Infection occurs directly and can enter intact plant tissue. As seedlings age, they become less susceptible to attack.

Host Range

Most vegetables are susceptible to Rhizoctonia. However, there are many strains of the fungus; each with its own host range. Rhizoctonia is known to affect peas, lima beans, garden beans, egg plant, peppers, spinach, sweet potatoes, tomatoes, broccoli, cabbage, cauliflower, garden cress, cucumber, kale, lettuce, peppers, radish, potatoes, celery, rhubarb, escarole, onions, yams, beets, carrots, and turnips. Strains of the fungus from one host or a group of hosts often do not infect other hosts.

Environmental Factors

Disease development is temperature dependent and is most severe when soil surface temperatures are between 75-85 degrees F. Because sandy soils warm up relatively rapidly, Rhizoctonia seedling blight is often more serious on these soils. Higher soil and air moisture is more conducive to the disease than drier conditions.

Symptoms

The browning of stems and death of very young pea seedlings is the most common above-ground symptom of Rhizoctonia seedling blight. Up to 1/2 inch of the terminal shoot is affected just as it emerges through the soil and before the leaves expand. Often one or two auxiliary shoots arise from the seed within a few days after the first shoot dies back. These auxiliary shoots also may become infected or they may produce a normal, but late plant.

Scouting Procedure/ET

There are no monitoring practices recommended because there is no control for rhizoctonia once it has begun. Proper identification of suspected symptomatic plants is recommended so planning for future plantings in infested fields may be done. There are no soil assays to determine the level of inoculum.

Integrated Control

Non-Chemical Control

Cultural Control: Cultural practices which reduce the inoculum in the soil aid in the control of this disease. Good soil drainage and weed management are important in control of Rhizoctonia. Rotate peas with crops known to be relatively poor hosts for the fungus such as grain crops and corn. Harvest crops promptly when they are fully mature. Till under all crop refuse so it will decompose quickly. Fertilize adequately so that plants can outgrow the early susceptible stage.

Resistant Varieties: There are no known pea varieties which are resistant to Rhizoctonia.

Chemical Control

None.

Fungicide Resistance: None.

References

Compendium of Pea Diseases. 1984. American Phytopathological Society. St. Paul, MN. 57pp.

Hagedorn D. J. 1976. Handbook of pea diseases. University of Wisconsin Extension Service Publication A1167. 41 pp.

Contents Potato (PO)

Verison 2.0 Printed 6/99

UW Extension

Diagnostic Guide

Potato Growth Stages

1 - Pre-emergence to emergence

General Appearance	Specific Symptoms	Cause (s)
Poor stand, skips in rows	No seedpiece found	Planter malfunction Empty planter box Irregular planting depth Bacterial or fungal decay
	Seedpiece not sprouted	Treated with sprout inhibitor Soil too cold Soil too dry Lack of tuber eye Excessive fertilizer in contact with seed Herbicide injury Storage condition-tubers production w/o sprouts
	Rotted Seedpiece	Fungal or bacterial decay Excessive fertilizer Seedpiece frozen Seedcorn maggot injury Soil too wet
	Sprouts twisted or malformed underground	Soil crusted Herbicide injury Planting depth Cold temperature
	Sprouts girdled underground	Rhizoctonia canker Cutworms
Seedpieces eaten, dug up, or sprouts cut off	Seedpiece hollowed out	Wireworms, white grubs, mice, moles
	Seedpieces and sprouts dug up and parts eaten	Deer, rodents, birds
	Sprouts cut off	Cutworms, rodents. Mechanical injury - farm implements

2 - Emergence to Row Close

General Appearance	Specific Symptoms	Cause (s)
Uniform patterns of dead or poorly growing plants	Plants suddenly killed or injured	Frost Herbicide injury current year Residual herbicide (carryover) *(Note previous cropping history)*
	Plants stunted with uneven growth	Herbicide injury, current year or carryover Improper fertilizer dosages or placement Mechanical injury Uneven planting depth
	Plants with malformed growth	Herbicide injury current year or carryover *(Note cropping history such as fertilizer placement, other pesticides)*
Scattered areas of dead or poorly growing plants	Plants suddenly killed	Frost Lightning Excess water Sprayer overlap or mistakes Residual herbicides
	Plants stunted with uneven growth	Variation in soil type Uneven planting depth Soil drainage problems Root rot complex Sprayer overlap Herbicide residual
	Plants stunted and malformed	Herbicide injury or any of the above Cold injury
	Plants with leaf tissue removed Shot holes (less than 1/8") Larger holes	Insect feeding Flea beetle Loopers, cutworms, Colorado potato beetle
Widespread areas of dead or poorly growing plants	Plants stunted with uneven growth	Variation in soil type Uneven planting depth Soil drainage problems Soil compaction Root rot complex Herbicide residual previous crop
	Plants stunted and malformed	Herbicide injury or any of above
	Plants discolored	Nutritional deficiency Herbicide injury Wind (sand) injury
	Plants with leaf tissue removed Shot holes Larger holes	 Fleabeetle Loopers, cutworms, Colorado potato beetle
	Plants with leaf tissue removed or torn	Hail injury Wind injury

2 - Emergence to Row Close

General Appearance	Specific Symptoms	Cause (s)
Individual plants dead or growing poorly (random distribution)	Plants individually killed	Blackleg
	Plants stunted with uneven growth	Root rot complex Nematodes Virus infection
	Plants stunted and malformed	Virus infection
	Plants parts wilted	Potato Aphid European Corn Borer Hop vine borer Tarnished Plant bug
	Plants discolored	Virus infection
	Plants with leaf tissue removed	Insect feeding. Check for additional plants with feeding injury

3 - Row Close to Vine Kill

General Appearance	Specific Symptoms	Cause (s)
Uniform patterns of dead or poorly growing plants	Plants stunted with uneven growth	Herbicide injury Soil drainage problems Irrigation problems (pipe leaking, nozzle malfunction)
	Plants with malformed growth	Herbicide or other pesticide injury
Scattered areas of dead or poorly growing plants	Plants suddenly killed	Frost Lightning Water excess
	Plants stunted with uneven growth	Variation in soil type Soil drainage problems Root rot complex Nematodes
	Plants stunted and malformed	Herbicide injury Virus infection Hopper burn
	Plants stunted and/or wilted without leafroll	Root rot complex Verticillium wilt Nematodes Variation in soil types Ring rot
	Plants stunted with upward leafroll and light green cast	Leafroll virus Hopper burn
	Plants with leaves abnormal in color	Senescence Nutrient deficiency Herbicide injury Soil pH Root rot complex Verticillium wilt Nematodes Blackleg Purple top Leafroll virus Water stress

3 - Row Close to Vine Kill

General Appearance	Specific Symptoms	Cause (s)
	Plant with leaf tissue removed Shot holes Large holes Irregular feeding damage Extensive feeding	Insect feeding Fleabeetle Cutworms, loopers, armyworms, grasshoppers (field margin) Colorado potato beetle Black Blister beetle
	Plants with tip or marginal necrosis	Hopper burn Systemic insecticide overdose Nutrient deficiency
	Plants with leaves having surface markings or lesions	Air pollution damage Late blight Early blight Fertilizer burn Pesticide burn
	Plants with stems showing water soaked lesions	Blackleg White mold Gray mold Late blight
Widespread areas of dead plants or plants with abnormal symptoms	Plants suddenly killed	Vine killer applied
	Plants stunted with uneven growth	Herbicide injury Irrigation problems Root rot complex Nematodes Hopper burn
	Plants with malformed growth	Herbicide or other pesticide injury Cold temperature
	Plants stunted and/or wilted	Root rot complex Verticillium wilt Nematodes High aphid populations
	Plants discolored	Root rot complex Nutrient deficiency Hopper burn Senescence
	Plants with leaf tissue removed or torn	Hail injury Wind injury Tarnished Plant Bug
	Plants with leaves having surface markings or lesions	Air pollution damage Late blight Early blight Fertilizer burn Pesticide burn

3 - Row Close to Vine Kill

General Appearance	Specific Symptoms	Cause (s)
Individual plants dead or growing poorly (randomly distributed)	Plants individually killed	Blackleg Root rot complex European Corn Borer Ring rot Hop vine borer
	Plants stunted and malformed	Virus infection
	Plants stunted with uneven growth	Virus infection Root rot complex Nematodes
	Plants stunted and/or wilted without leafroll	Root rot complex Verticillium wilt Nematodes Blackleg
	Plants stunted with leafroll	Leafroll virus Hopper burn
	Plants with leaves abnormal in color	Water stress Root rot complex Verticillium wilt Nematodes Blackleg Virus infection Purple top Leafroll virus
	Plants with leaf tissue removed Shot holes Large holes	Insect feeding (check adjacent plants) Fleabeetles Cutworms, loopers, Colorado potato beetle, Black Blister Beetle
	Plants with leaves having surface markings or lesions	Early blight Late blight
	Plants with stems showing water soaked lesions	Blackleg White mold Gray mold Late blight

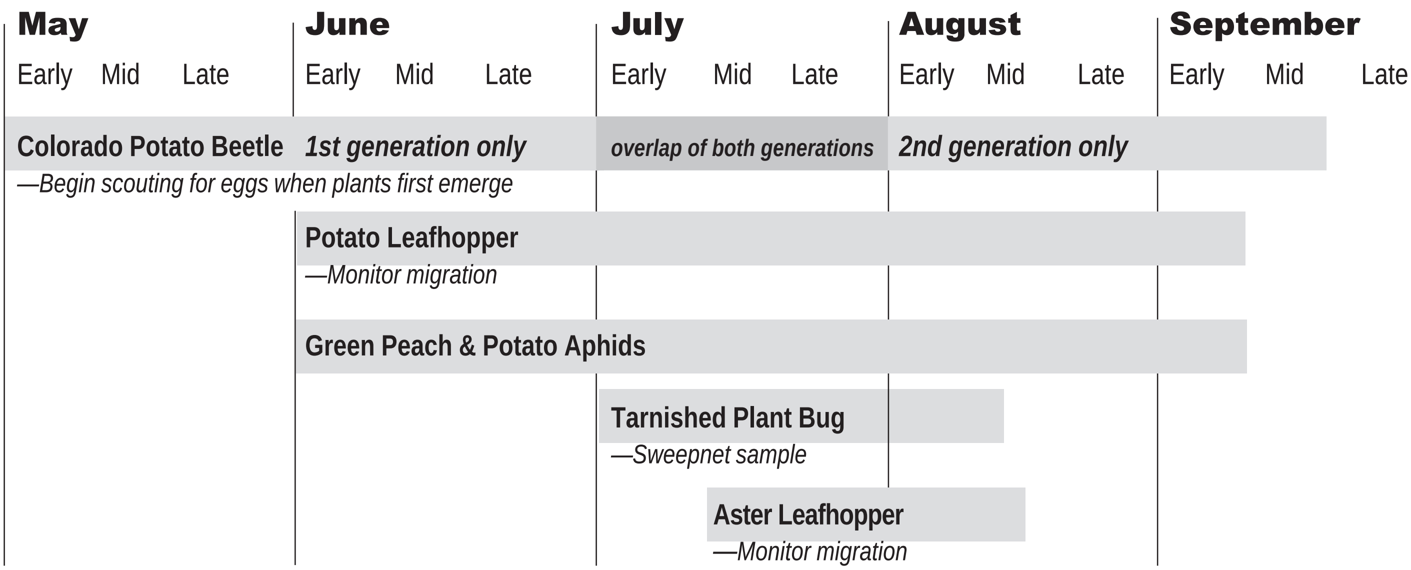
4 - Mature Tuber

See Agriculture Handbook No 474 , Potato Diseases for KeyTuber Diseases and Disorders

Notes

Scouting Calendars

Potato Insect Pests in Wisconsin



Potato Disease Scouting Table

Diseases	**Temperature**	**Climate**	**Occurrance**
Bacterial Ring Rot	soil temp= 65-70° F	hot, dry	Row close—vine kill
Bacterial Soft Rot	tubers at 68-78° F	warm, rainy	
Black Dot Root Rot	soil temp= 60-85° F	moist soil; stressful conditions	
Black Heart		high temps, flooded fields	
Blackleg	> 65° F	moist soils	emergence—vine kill
Common Scab		warm, dry soils; early stress soil pH = 5.5-7.5	
Early Blight	75-85° F *(spore germination)*	moderate temps, high humidity, prolonged leaf wettness	Row close—vine kill
Early Dying		wet soils*(emergence)*; hot soils *(tuber bulking)*	
Fusarium Dry Rot	68-78° F	high storage temps & high humidity	
Fusarium Wilt	85° F	cool & wet soil favors infection *(early season)* hot weather, wet soil favors development	
Gray Mold		cool temps, / high humidity	Row close—vine kill

—continued on back

Diseases	Temperatures	Climate	Occurrance
Late Blight	nights = 50-60 F days = 60-70 F	cool, moist weather	row close—vine kill
Leaf Roll		moderate temps, dry weather	row close—vine kill
Leak	77 F	hot, wet weather	
Phoma Tuber Rot		cool, dry storage conditions	tuber infection in storage
Potato Latent Virus	60-68 F	cool	emergence—vine kill
Rhizoctonia Canker		cool soil temps, high moisture and fertility	pre-emergence to emergence
Rugose Mosaic Virus		weather that favors aphids	emergence—vine kill
Silver Scurf		high soi temps. and humidity	
Simple Mosaic Virus		weather that favors aphids	emergence—vine kill

Potato Pest Management Form

Grower__________________. Field #__________________. Field Location__________.

Field Size__________________. Date____________________. Hour __________________.

Plant Height__________________. Growth Stage____________. Scout __________________.

Insects	Thresholds	Field Average	Field Tally
1. PLH	25/25 sweeps	__/25 sweeps	__________________
2. PA	25/25 sweeps	__/25 sweeps	__________________
3. PLHN	1.5/15 leaves	__/15 leaves	__________________
4. GPA	1.5/15 leaves (seed potatoes)	__/15 leaves	__________________
	15/15 leaves (table stock)	__/15 leaves	__________________
5. CPBA	25/5 ft. row	__/5 ft. row	__________________
6. CPBL	75/5 ft. row	__/5 ft. row	__________________

Cutworms and Loopers

7. Instar 1&2		__/5 ft. row	__________________
8. Instar 3	20/5 ft. row	__/5 ft. row	__________________
9. Instar 4	20/5 ft. row	__/5 ft. row	__________________
10. Instar 5&6		__/5 ft. row	__________________

Cutworm head capsule gauge

Cutworm body length gauge

Field Map / Comments:

Diseases

1. Early Blight __________________
____
2. Late Bligh __________________
____
3. Other

Horsfall-Barratt Disease Rating System:

0 = no foliage infected	6 = 50-75%
1 = 0-3%	7 = 75-88
2 = 3-6	8 = 88-94
3 = 6-12	9 = 94-97
4 = 12-25	10 = 97-100
5 = 25-50	11 = all foliage infected

Notes

Armyworm

Scientific Name: *Pseudaletia unipunctata*
Order: Lepidoptera
Family: Noctuidae

General Information

Biological Description

The armyworm is generally not a problem on vegetable crops; it prefers grasses and grains. However, grass weeds in potato fields will attract moths. Outbreaks are more common following cold, wet, spring weather. The sand-colored moths have a wing span of 1.5" with definitive white dots in the center of each forewing and dark markings on the hind wings. The brownish-green larvae are hairless, have alternate dark and light stripes down their backs and are about 2" long when fully grown. The head is pale brown with dark markings. Pupae are dark brown and approximately 3/4 inch in length. They are sharply tapered at the tail end with a much more rounded head end. The greenish white eggs are laid in rows or clusters on leaves. Moths often seem to congregate in certain locations. Armyworms often are confused with the variegated cutworm and other related species.

Economic Importance

Damage is sporadic and dependent on heavy flights of southern moths reaching Wisconsin.

Life Cycle

It is not known if the armyworm overwinters in Wisconsin. The moths usually appear in late April and early May. Most of the early season moths are immigrants from southern states. Once they arrive, they immediately mate. Eggs are laid in the evening and at night in rows or clumps of many eggs. Grasses and small grains are the preferred host and blades are often folded and sealed to protect the eggs. One week to 10 days after the eggs are laid, the larvae emerge and begin to feed. After feeding for 3-4 weeks, the full-grown larvae pupate for an additional 2 weeks and emerge as adults. There are 3 generations per season, with each generation lasting 5-6 weeks. The first generation is small and does little damage, however the success of this generation, produces later, more injurious, generations of armyworms. The second larval generation which appears in July, is the largest and most damaging generation to Wisconsin crops. The fall generation is typically not injurious and is often heavily parasitized by beneficial insects, fungi and viruses.

Host Range

Armyworms attack all grasses, particularly wheat, oats, corn barley and rye and some legumes; but when under stress, armyworms will attack neighboring vegetable crops and seedling alfalfa. Additionally, the presence of grass weeds in vegetable fields will attract moths for egg laying.

Environmental Factors

Cold, wet spring weather precipitates armyworm outbreaks.

Damage/Symptoms

Larvae tend to feed at night or on cloudy days and hide in the soil or under foliage during the day. On older plants they may eat moderate amounts of foliage with young larvae concentrating on terminal growth while older larvae feed near the ground. Damage is usually highest along the field edge or in grassy spots.

Scouting Procedure and ET

Timely detection is critical if post-emergent insecticidal treatment is to be effective. When feeding damage is observed, shake 5-foot sections of 2 adjacent rows and count larvae on soil surface. Repeat in several locations since infestations may be restricted to certain areas. Damage usually begins along field edges and moves inward as the insects migrate. Spot treat if possible when two larvae/1 foot of row are observed.

Integrated Control

Non-Chemical Control

Natural Control: A number of braconid wasps and tachinid flies help keep armyworm numbers down, as do birds, toads, skunks and some domestic fowl. Armyworms are only problematic in grassy areas.

Cultural Control: Since female moths prefer to lay eggs in grassy areas, keeping grassy weeds controlled will lessen the possibility of problems. Avoid planting susceptible crops in low wet areas or in rotations following sod. If this is unavoidable, be sure to plow in the fall of the previous season to decrease early spring egg-laying sites. Killing grass with a herbicide or tillage may drive armyworms to the susceptible vegetables.

Biological Control: Several natural enemies exist which may keep armyworm populations low. The red-tailed tachinid fly (*Winthemia quadripustulata*) is one such biocontrol agent. It lays its eggs on the armyworm's back and the tachinid larvae bore into larval armyworms to feed. In addition, several ground beetles and parasitic hymenoptera prey upon the armyworm. There is also and egg parasite (*Telenomus minimus*) that is effective in preventing egg hatch and subsequent larval feeding damage.

Chemical Control

Commercial: Carbaryl, esfenvalerate, and methomyl are foliar

treatments which are labeled for the control of armyworms. Refer to the product label for more information on specific application instructions and precautions.
Homeowner: Apply carbaryl bait if extensive foliage feeding observed.
Insecticide Resistance: None.

References

R. H. Davidson and W. F. Lyon (1987) Insect Pests 8th Ed. of Farm, Garden, and Home. John Wiley & Sons, New York.
C. L. Metcalf and R L. Metcalf (1993) Destructive and Useful Insects, their Habits and Control 5th Ed. McGraw-Hill Book Co., New York.

Aster Leafhopper

Scientific Name: *Macrosteles fascifrons*
Order: Homoptera
Family: Cicadellidae

General Information

Biological Description

The adult aster leafhopper is olive-green, wedge-shaped, and about 4 mm in length. They have three pair of spots on the vertex of their head. Nymphs are similar in shape to the adults, but are cream-colored and lack fully developed wings. Adults are extremely active and jump, fly, or crawl sideways or backwards when disturbed. Nymphs are less active but crawl rapidly, often seeking to regain the lower leaf surface when dislodged.

Economic Importance

The aster leafhopper is an occasional pest of potatoes because of its ability to transmit the mycoplasma-like organism (MLO) that causes aster yellows. On potatoes, this disease is called purple top.

Life Cycle

The first aster leafhoppers that appear in May and June do not overwinter in Wisconsin. This insect overwinters in the Gulf states and migrates northward each spring on warm, southerly winds. The first migrants are primarily female. Large influxes may occur in June and early July as local populations develop. Eggs are laid under the epidermis of leaves of susceptible hosts. The leafhoppers progress through five nymphal instars and require 20-30 days for development. There are normally two to five generations per year.

Host Range

Both the aster leafhopper and the aster yellows disease have broad host ranges of over 200 plant species in many different families. The leafhopper prefers lettuce and small grains for feeding and breeding, while other crops such as potatoes, tomatoes, and onions provide a temporary source of food and refuge. These temporary sites are utilized only by the adults as the nymphs fail to develop on these plants.

Damage/Symptoms

Leafhopper feeding alone does little damage to the plant. However, it is the transmission of the aster yellows pathogen that causes problems. Newly sprouted potatoes are the most susceptible stage; mature plants are almost totally resistant to aster yellows. If young plants do become infected, symptoms may not be expressed for 30 days or more. General aster yellows symptoms on potatoes include yellowing and reddening of mature foliage, and aerial tuber formation. Infected plants are generally stunted and have small tubers. Infected tubers which are processed, will result in a dark-colored product. An infective leafhopper transmits the pathogen to a plant during its feeding activity. The pathogen is carried in the insect's saliva and is transmitted to the phloem vessels when the leafhopper feeds on plant sap. On average, the leafhopper must probe and feed on a host for eight hours before the pathogen is transmitted. The aster yellows MLO can multiply in both the plant and in the insect vector. The pathogen must multiply in the vector for at least three weeks before it is passed into the salivary glands and is able to be transmitted. After the incubation period, the leafhopper is infective for the remainder of its life.

Scouting Procedure/ET

Begin scouting for aster leafhoppers early in the spring when plants are newly sprouted. Scout for adult aster leafhoppers by taking 25 sweeps per sample site with an insect sweep net. Sample st least five sites per 30 acres and add one sample site for each additional 20 acres. The need for treatment is determined by an index which is based on the number of leafhoppers per 100 sweeps times the percent infectivity of the migrant population. Treat potatoes at an index of 200. For example: if the percent of infectivity is 1%, treatment would be necessary at 200 leafhoppers per 100 sweeps. The percent of infectivity is available from the UW Extension.

Integrated Control

Non-Chemical Control

Natural Control: There are no effective natural controls for aster leafhoppers, although there will be fewer migrants in the absence of southerly winds in May.
Cultural Control: Elimination of infective weed reservoirs can reduce the spread of aster yellows to vegetable crops. Compared with other vegetables such as carrots and lettuce, potatoes are quite resistant to aster yellows.

Biological Control: There are no effective biological control agents to use to reduce aster leafhopper populations.

Chemical Control

Commercial: Current pest management for aster leafhoppers on potatoes calls for insecticide treatment when populations exceed the economic threshold level or index of 200. If systemic insecticide was used, no further treatment should be necessary. If foliar treatments are required, the highest recommended labeled rate is suggested to achieve control. Asana, Lannate, Monitor, Ambush, and Pounce are registered for control of aster leafhoppers on potatoes. Refer to the product label for specific application instructions and precautions.

Homeowner: Sevin will effectively control aster leafhoppers in small gardens. In areas where leafhoppers and aster yellows are routinely a problem, increasing the size of the crop to account for crop loss to disease may be useful.
Insecticide Resistance: None.

References:

C.L. Metcalf and R. L. Metcalf (1993) Destructive and Useful Insects, Their Habits and Control. 5th Ed. McGraw-Hill Book Co., New York.

R.E. Foster and B. R. Flood ed. (1994) Midwest Vegetable Insect Management. Purdue University Agricultural Experiment Station. West Lafayette, IA.

L.N. Chiykowski and R. K. Chapman. 1965. Migration of the Six-spotted Leafhopper in Central North America. Research Bulletin 261, University of Wisconsin - Madison.

Blister Beetle

Scientific Name: *Epicauta spp.*
Order: Coleoptera
Family: Meloidae

General Information

Biological Description

There are a number of species of blister beetles that cause similar damage in Wisconsin. All species are slender beetles which are about four times as long as they are wide. Adults are black to ash grey in color and may or may not have grey or yellow stripes on the wing cover. Adults contain an irritating oil which will blister tender skin if crushed. The larvae are predators of grasshopper eggs.

Economic Importance

Blister beetles are an occasional pest of potatoes as the adults are general foliage feeders. Although larvae are considered beneficial, they rarely destroy more than 25% of the grasshopper egg masses.

Life Cycle

The life history of this insect is very complex and is closely related to the number of grasshoppers that are present since beetle larvae are predators of grasshopper eggs. Adult females beetles lay up to 300 elongated, yellow eggs in the soil during the summer. Larvae emerging from these eggs are very active and immediately seek grasshopper eggs on which to feed. Throughout the course of the summer the larvae complete five instars. Blister beetles overwinter as sixth instar pseudopupa. Adults emerge in late June. There is one generation per year in Wisconsin.

Host Range

Adult blister beetles feed on all members of the *Solanaceae* family, melon, beets, and other vegetables, flowers and weeds.

Environmental Conditions

Dry summer weather favors an increase in grasshopper populations and, as a result, blister beetle populations also increase the following season.

Damage/Symptoms

Large clusters of adult blister beetles can be found feeding on potato foliage from late June through August. Beetles may appear overnight. If over 20% of the leaf tissue has been removed at the time of flowering, the damage is considered significant.

Scouting Procedure/ET

No thresholds have been established for this insect. An estimate of the percentage of infested plants and the percentage of the foliage consumed will help in management decisions. Since beetles cluster while feeding, damage may appear more severe than it really is. Defoliation of 20% or more at flowering is significant. At other stages of plant development damage is less critical.

Integrated Control

Non-Chemical Control

Natural Control: Any efficient grasshopper control will reduce the populations of blister beetles. Since grasshoppers do well during dry summers, blister beetles populations will be higher the year after drought. No significant natural predators or parasites are known.
Cultural Control: No effective cultural controls have been described.
Biological Control: There are no commercially available biological control agents which are cost effective to use to reduce aster leafhopper populations.

Chemical Control

Commercial: Because blister beetles are not a serious problem in potato, chemical controls are not recommended.
Homeowner: None.
Insecticide Resistance: None.

References:

C.L. Metcalf and R. L. Metcald (1993) Destructive and Useful Insects, Their Habits and Control. 5th Ed. McGraw-Hill Book Co., New York.

Cabbage Looper

Scientific Name: *Trichoplusia ni*
Order: Lepidoptera
Family: Noctuidae

General Information

Biological Description

The cabbage looper adult is a grayish-brown, night-flying moth with a wing span of 1.5". The mottled brown forewings are marked near the middle with a small silver-white figure-8 or letter-Y. Hind wings are uniformly brown. The caterpillar (larva), is called a looper because of the way it arches its body while moving. Mature larvae are up to 1 1/2 inches long, have a greenish body which tapers at the head end with a thin white line along each side, two longitudinal white lines on the middle of the back. There are three pair of prolegs at the distal end of the abdomen. Eggs are small, round and white in color and laid singly under the leaves near the edge. Pupae, which are enclosed in a loosely woven silken covering, are brown and 1/2-3/4 inches long.

Life Cycle

Cabbage loopers probably do not overwinter in large numbers in Wisconsin, but migrate in from the south mid-July through September. Overwintering pupae give rise to the first generation adults in spring. White eggs are laid singly on the lower leaf surfaces in June. Larvae mature through 5 successively larger instars over the next 4-5 weeks before leaving the plant to pupate. Adults emerge in 10-14 days, mate, and lay eggs which give rise to the second generation. Second generation cabbage loopers cause the most damage in August and September.

Host Range

Host plants include beets, cole crops, celery, lettuce, mint, peas, potato, spinach and tomato.

Damage/Symptoms

Larvae feed high on the plant and are usually easily seen. They chew large holes in the foliage, but are rarely present in damaging numbers in potatoes. Most damage is caused by the second generation of larvae in August.

Scouting Procedure/ET

Shake the foliage of five foot sections of two adjacent rows into the furrow and count the larvae on the soil surface. Divide the number of larvae counted by five. The resulting number is the number of worms per row foot. Sample at least five sites per 30 acres and add one additional sample site for each additional 20 acres.
Prior to July 25: Control measures are recommended if the cutworm and looper counts exceed four per row foot as a field average.
After July 25: Control measures are recommended if the cutworm and looper counts exceed eight per row foot as a field average.

Integrated Control

Non-Chemical Control

Natural Control: Natural controls are frequently quite effective in holding looper populations down. An egg parasite (trichogramma), several larval parasites and an egg-larval-pupal parasite (copidosoma) may become numerous. Several general predators attack the egg and larval stages. An NPV wilt disease kills nost of the looper population in late summer.
Cultural Control: Spring plowing of debris and clean culture are good insurance against potentially overwintering cabbage looper pupae.
Biological Control: There are no commercially available biological control agents which are cost effective to use to reduce looper populations.

Chemical Control

Commercial: Current pest management recommendations for loopers and cutowrms calls for insecticide treatements when populations exceed threshold levels. Spot treatments can be effective when "hot spots" exhibit high numbers and yet the field average remains below threshold. Insecticides registered for control of loopers include endosulfan, esfenvalerate, permethrin, methomyl, methamidophos. Refer to the product label for specific application instructions and precautions.
Homeowner: Chemical treatment is seldom necessary. Hand-pick larvae or treat with *Bacillus thuringiensis* if necessary to reduce the impact on beneficial insects.
Insecticide Resistance: None.

References

R. H. Davidson and W. F. Lyon (1987) Insect Pests 8th Ed. of Farm, Garden, and Home. John Wiley & Sons, New York 640 pp.

C. L. Metcalf and R. L. Metcalf (1993) Destructive and Useful Insects, their Habits and Control 5th Ed. McGraw-Hill Book Co., New York.

Colorado Potato Beetle

Scientific Name: *Leptinotarsa decemlineata*
Order: Coleoptera
Family: Chrysomelidae

General Information

Biological Description

Adult Colorado Potato beetles are hard-shelled, broad (3/8 by 1/4 inch), convex, yellow beetles with 10 black longitudinal lines on the wing covers, and black spots behind the head. The larvae are fat, red-orange, hump-backed, worm-like insects with black legs and head, and black spots along the sides of body. Eggs are bright yellow and laid in clusters on the underside of foliage.

Economic Importance

If left unchecked, feeding activity of the Colorado potato beetle larvae and adults can completely defoliate potato plants, resulting in reduced tuber size or plant death.

Life Cycle

Colorado potato beetles overwinter as adults in the soil 2-8 inches deep, often at field margins. Adults become active in the spring, about the time the first shoots of early season potatoes or volunteer plants appear. Females will lay up to 500 bright yellow eggs in clusters of 15-25 on the lower leaf surfaces before dying. Eggs hatch in 4-9 days and larvae begin feeding immediately. After passing through four instars over the course 2-3 weeks, larvae return to the soil to pupate. Within 10-14 days, adult beetles emerge. There are 2 generations/year in most of Wisconsin.

Host Range

Potato is the preferred host but beetles also feed on eggplant. Weeds such as nightshade, groundcherry, jimsonweed, horsenettle, and mullein can also serve as hosts.

Environmental Factors

Cool weather tends to slow insect activity and development thereby reducing the amount of damage that occurs. Conversely, warm spring weather may accelerate insect growth so that a complete second generation will develop before the end of the season.

Damage/Symptoms:

Both adults and larvae are voracious leaf feeders. Large holes, larger than 1/8 inch in diameter, are chewed into potato leaves. Often, entire leaves on the terminal parts of plant are consumed. Larvae typically feed in groups and may completely defoliate plants. The late larval instars do the most feeding damage. Heavy defoliation will severely affect plant yields, particularly if it occurs when potatoes are in the flower stage.

Scouting Procedure/ET

Egg Masses Start scouting for bright yellow egg clusters in early May by examining the lower surfaces of all leaves on a plant. Sample five consecutive plants per sample site. Sample at least five sites per 30 acres and add one sample site for each additional 20 acres.

Overwintered Adults Overwintered adults are normally found on newly emerging plants in May and are frequently concentrated on field edges close to overwintering sites. Due to low average temperatures in May, overwintered adults normally do not feed enough to cause severe defoliation. Chemical treatments are also ineffective at this time because of the continued beetle migration into fields and the rapidly growing potato foliage. Sprays should be avoided at this time. If temperatures are high, feeding will increase and a treatment should be made to reduce beetle numbers if defoliation exceeds 20-30% on infested plants. Spot treatments are very effective in controlling overwintering or migrating adults.

First Generation Larvae First instar larvae are small, blackish-brown and frequently congregate on expanding terminal foliage where feeding damage is inconsequential. Second instar larvae begin to assume the more typical brown-red larval coloring, and although feeding damage on terminal growth is more evident, damage from second instars will not be severe enough to require treatment. Third and fourth instar larvae are reddish-brown and foliage consumption increases rapidly as larvae enter the third instar. Accurate counts of small larvae are difficult to obtain due to the clustering of larvae in expanding terminal foliage and a count of the proportion of infested plants (those with 10 larvae/plant or more) per sample unit is a more accurate measure of infestation. Treatments should be delayed whenever possible until larvae reach the third instar to allow as many eggs as possible to hatch and still avoid potential damage by third instar larvae.

Degree day accumulation can be used to accurately predict the occurrence of third instar larvae. A base temperature of 52^{o}F is used and accumulation is begun when the first egg mass is found in the field. Begin scouting for egg masses in May. Degree day accumulations for Colorado Potato Beetles are as follows:

Life Stage	DD_{50}	Cumulative DD_{50}
Egg	120	120
First Instar	65	185
Second Instar	55	240
Third Instar	60	300
Fourth Instar	100	400
Pupae	275	675

When 240-250 DD_{50} have accumulated from the first egg deposition, the first larvae will be entering the third instar stage and the bulk of larvae will be in the second instar. A treatment should be applied at this time if larval infestation is greater then 2 infested plants/25 on a field average. Since larvae are normally clustered near field edges, spot treatments are very effective and should be used to control Colorado Potato Beetles in high infestation areas

even though field averages may be lower than the threshold. Fields should be scouted regularly during egg laying and if egg-laying is prolonged, a second insecticide application should be made 100-150 DD_{50} after the first to control larvae which were in the egg stage when the first application was made.
Selection of sample sites should depend on the infestation pattern. Full coverage of the fields is necessary to ensure that overall infestation patterns are identified, but since infestations are frequently clumped near field edges, sampling may be concentrated in these areas to allow spot spraying recommendations to be made. Plant samples of 25 consecutive plants should be used in egg, larvae, and adult samples. Larvae and adults can be counted visually but to accurately determine egg numbers, leaves must be overturned.

<u>Second Generation Adults</u>

Second generation adults normally appear in mid-July and may cause severe defoliation. When temperatures are above normal in June and July, second generation adults may produce a second generation of larvae. Under normal conditions, these adults produce only a partial second generation and then seek overwintering sites.
Defoliation pressure from second generation Colorado Potato Beetle adults is estimated from counts of adults on plants in each of the sampling areas. Count the number of Colorado Potato Beetle adults on a total of 25 plants in each sampling location in the field. Divide the total number of insects by 25 to determine the average number of adult beetles per plant. If the average exceeds 3 beetles per plant, control measures are recommended.

Integrated Control

Non-Chemical Control

Natural Control: A number of predaceous bugs, two species of parasitic tachinid flies, and some birds may reduce populations of Colorado Potato beetle however, none of these are particularly effective.

Cultural Control: Colorado potato beetles have limited host ranges and thus crop rotations which avoid solanaceous plants, in conjunction with the removal of alternate host weeds, will reduce populations effectively. Trap crops consisting of strips of early-planted potatoes on field edges next to overwintering sites may be used to concentrate beetles for physical control. Propane flamers and vacuum suction have been used for beetle removal. Plastic-lined trenches located between fields and overwintering sites have also been effective.

Biological Control: There are no commercially available biological control agents which are cost effective to use to reduce populations of the Colorado potato beetle

Chemical Control

Commercial: Systemic recommendations for the control of Colorado potato beetles fall into one of three options:

<u>Option 1</u> Thimet/Phorate applied at 2 lb ai/A at the time of plant emergence on irrigated crops or in the furrow at planting on dry land. This rate may be increased to 3 lbs ai/A on heavy soils. Do not use on muck soils. Thimet/Phorate will only provide early season control.

<u>Option 2</u> Disyston applied at 3 lbs ai/A at planting or plant emergence on irrigated crops or in the furrow at planting on dry land. Do not use on muck soils. Only provides suppression of the Colorado potato beetle so the crop should be scouted regularly and a foliar spray program initiated when needed.

<u>Option 3</u> Admire applied in the furrow at 0.2 to 0.3 lbs ai/A will provide virtually season long control. A 12 month plantback restriction prevents planting crops other than potatoes for 12 months following application.

Foliar sprays are generally the most effective means of controlling the Colorado potato beetle and can be used alone or in combination with systemic insecticides. Two considerations are critical when planning a spray program: 1) Avoidance of insecticide resistance - Resistance is a very serious threat to continued effective Colorado potato beetle control. Wisconsin populations are still susceptible to a wide range of insecticides, but repeated use of any one material can rapidly lead to loss of efficacy. 2) Timing of applications - Application timing allows growers to accurately target needed sprays against only vulnerable life stages. This strategy keeps sprays to a minimum and avoid excessive selection of resistant beetles.
The most vulnerable life stages of the Colorado potato beetle are the larval instars resulting from eggs laid by overwintered adults. These stages normally occur during June with maximum damage caused by fourth instar larvae in late June. Degree day accumulations can be used to predict development of larvae. Foliar sprays should be timed as follows: <u>Overwintered adults</u> which are continually moving onto the emerging crop in May are hard to control on small, rapidly growing plants. Defoliation is limited by cool temperatures and plants are tolerant at this stage. Controls should only be attempted if defoliation approaches 20-30%. Infestations are often limited to the field edges of "hot spots" and spot treatments should be used when feasible. If a spray is needed, an organophosphate, carbamate, or organochlorine should be used in preference to pyrethroids which should be reserved for the main larval control spray. <u>Eggs</u> are not susceptible to chemical control. Larval instars are the most easily controlled stages Of the four instars, 1st and 2nd instars do very little damage and growers should delay larval sprays until 3rd instar larvae are present. Delaying the main larval spray until this point will allow as many eggs as possible to hatch into susceptible larvae and at the same time, avoid the damaging 4th instar where most larval feeding occurs. Consult defoliation thresholds to make sure damage does not surpass the threshold while larval treatment is delayed. If thresholds are approached, an earlier spray should be considered. Larval sprays must be applied before the 4th instar leaves the plant and enters the soil to pupate. Pyrethroid insecticides should be used for the main larval control sprays.
If egg-laying continues after the main larval spray is applied, it may be necessary to apply a late larval spray about 150-200 DD after the main spray. An organophosphate, organochlorine, or biological

insecticide should be used for this spray.

An additional strategy to control larvae and avoid resistance is to incorporate a biological insecticide early into the program. These bacterial insecticides are only effective against first and second instar larvae and thus they should be utilized as an early spray at 150 DD or as a late spray applied 150 DD after the first pyrethroid application. Bacterial insecticides have short persistence (1-2 days) and should be applied weekly for 2-3 applications if used alone.

Pupae reside in the soil and are not susceptible to chemical control.

Second Generation Adults which emerge in July are mobile and can cause serious damage when potatoes are still susceptible (at flowering). Use adult sprays at defoliation thresholds and consult scouting reports for other insect control needs.

Defoliation Thresholds

Varying levels of defoliation due to Colorado potato beetle feeding can be tolerated by potato plants without yield loss depending on the plant growth stage:

When plants are 6-8 inches (preflowering), treat at 20-30% defoliation.
If plants are flowering, treat at 5-10% defoliation.
If plants are mature, treat at 30% defoliation.

Chemical classes should be alternated. The following insecticides have demonstrated good efficacy in UW trials: pyrethroids - Asana, Ambush, Pounce; organophosphates - Guthion, Imidan; organochlorines - Thiodan; carbamates - Furadan; nicotinyls - imidacloprid (Provado); biologicals - Foil, Mtrak, Novodor; others - Cryolite, Kryocide. Pyrethroid synergists (piperonyl-butoxide; Butacide) may increase pyrethroid efficacy. If the population of second generation adults is large, and a significant amount of egg-laying occurs, it may be necessary to treat for second generation larvae. For specific foliar insecticide recommendations, consult UWEX publication A3422 "Commercial Vegetable Productionin Wisconsin". Refer to the product label for specific application instructions and precautions.

Homeowner: Treat with carbaryl when larval populations exceed 1/plant in mid-season. Larvae and adults are large and easily identified and may be hand picked or removed with a net in small plantings.

Insecticide Resistance: Colorado potato beetles exist which are resistant to every class of insecticide currently registered for control.

References

C.L. Metcalf & R.L. Metcalf (1993) Destructive and Useful Insects, Their Habits and Control 5th Ed. McGraw-Hill Book Co., New York.

S. E. Rice Mahr, J. A. Wyman, E. B. Radcliffe, C. Hoy and D. W. Ragsdale. 1995. Potato: Chapter 5 in Midwest Vegetable Insect Management. R. Foster and B. Flood, Eds.

Common Stalk Borer

Scientific Name: *Papaipema nebris*
Order: Lepidoptera
Family: Noctuidae

General Information

Biological Description

The larvae are purplish-brown with longitudinal, off-white stripes running the length of their body. There is a purplish saddle band located behind a yellow head. They range from 1/2 to 1 1/2 inches long and are extremely active when disturbed. Adult moths have dark grey-brown forewings with numerous small, white spots. The wingspan is approximately 1 1/4 inches.

Economic Importance

The common stalk borer is a rare pest in potatoes.

Life Cycle

Adult female stalk borers lay up to 2,000 eggs in late August and September in grassy weeds, ragweed, pigweed, curly dock, burdock. The eggs overwinter and hatch in early spring (mid-April to early May). The tiny caterpillars can cause pinhole feeding in the leaves of seedling corn in late May in southern Wisconsin. As the larvae grow, the grass stems become too small and by late June larvae begin to migrate from the grassy field borders into the border rows of adjacent crops. Larvae are fully grown in late August and may bore into many stems before pupating in the soil. Adults emerge 2-6 weeks later (late August) and seek grassy areas in which to oviposit. There is one generation/year.

Host Range

The host range of the common stalk borer is comprised of over 170 species. This insect attacks virtually any plant large enough for it to bore into, including all beans, corn, and potatoes.

Environmental Factors

Poor weed control will favor outbreaks of the common stalk borer.

Damage/Symptoms

Larvae bore into the stems of potato plants and burrow within the stems. As a result of the burrowing activity, the plant parts above the point of feeding wilt and die. A small hole may be seen at the site of entry of the caterpillar. If plant stems are dissected, the caterpillar may still be present.

Scouting Procedure/ET

Damage may appear severe on field margins, but on a whole field basis usually involves less than 2% of plants. Record number of wilted plants/100 throughout the field to determine an average. No thresholds have been established.

Integrated Control

Non-Chemical Control

Natural Control: Populations seem to build and decline in 4-6 year cycles but the reasons for this are not understood. Natural enemies of the common stalk borer include a tachinid fly (*Gynmochaeta ruficornis*), an ichneumonid wasp (*Lissonota brunner*) and two brachonid wasps (*Meteorus leviventris* and *Apanteles papaipemae*).

Cultural Control: Cultural control is by far the most important control for this pest. Poor weed control during the previous year provides numerous oviposition sites and can result in extensive patches of crop damage the following year. Keep fall weeds, especially grasses, controlled to prevent egg laying. Mowing fence rows in mid-August as eggs are laid may also help to reduce next season's population.

Biological Control: There are no commercially available biological control agents which are cost effective to use to reduce stalk borer populations.

Chemical Control

Commercial: Because this is an infrequent pest of potatoes, chemical control is not recommended.

Homeowner: Cultural controls are recommended.

Insecticide Resistance: None.

References

R. H. Davidson and W. F. Lyon (1979) Insect Pests of Farm, Garden, and Home. 7th Ed. John Wiley & Sons, New York 596 pp.

C. L. Metcalf and R. L. Metcalf (1993) Destructive and Useful Insects, Their Habits and Control 5th Ed. McGraw-Hill Book Co., New York

Black & Variegated Cutworms

Scientific Name: *Agrotis ipsilon*, *Peridroma saucia*
Order: Lepidoptera
Family: Noctuidae

General Information

Biological Description

Black cutworm larvae generally feed at, or below the ground surface at night while the variegated cutworm is generally a climbing or foliage feeding cutworm that damages plants later in the season. Cutworms are active feeders on young foliage or stem tissue and will cut off many young seedlings in an evening. Black cutworms are large, greasy, dark gray larvae will curl up into a tight c-shape if disturbed. Mature, 6th instar larvae, are 1.5" long and have a grainy texture. The black cutworm larvae are easily confused with other cutworms, but generally damage crops earlier in the season than the other species. This cutworm is particularly problematic to the home gardener.

Variegated cutworm larvae have a distinct pale yellow dot on the mid-dorsal line of most segments and frequently a dark W on the 8th abdominal segment. The larvae have a smooth skin texture with a dark brown background and smaller areas of dark brown. The grey, nocturnal moth is similar to other cutworms, having distinctive dark markings on their forewings. Eggs are hemispherical with a sculptured texture. Adult cutworms are gray moths which have a series of distinctive dark markings on their forewings and lighter colored hind wings.

Economic Importance

Damage is not common on potatoes but heavy infestation can decimate stands so severely that replanting may be necessary.

Life Cycle

Black cutworm moths that appear in late May have migrated into Wisconsin from other states. Overwintering black cutworms in Wisconsin are rarely abundant enough to cause significant damage. Female moths lay hundreds of eggs either singly or in clusters. Oviposition is typically concentrated on low-growing vegetation such as chickweed, curly dock, mustards or plant residue from the previous year's crop. As a result, heavy spring weed growth, newly broken sod, previous crop and plant debris all increase the risk of black cutworm infestations. Generally, black cutworm moths will not lay eggs in fields that have already been planted. Young larvae (less than one-half inch in length) feed above ground. Larger larvae feed at, or just below the soil surface, although in fields with very dry soil conditions, the larvae may be found 2-3 inches deep. Cutting stage larvae may take as long as 34 days to pupate at temperatures of 60° F, while only 12 days may be required at temperatures of 75° F. There are three generations per year. It is the first generation which is active during May and June that causes the most damage.

Variegated cutworms overwinter in the soil as partially matured larvae or as soil-encased pupae. Adults emerge in June and lay several hundred eggs in clusters on grass, weeds, and vegetables. The variegated cutworm is not as closely associated with grasses as are other cutworm species. On hatching, the foliage-feeding larvae pass through 5-6 molts before tunnelling into the soil to pupate. Overall, the generation time is about 7-8 weeks. Second generation adults appear in late August and September. These adults lay eggs which develop into the overwintering larvae and pupae.

Host Range
Cutworm larvae attack a wide variety of vegetable and field crops, especially in the seedling stage.

Environmental Factors
Excessive rainfall may disrupt egg-laying. Flooding may force larvae to the soil surface during the day where they are attacked by parasites or predators.

Damage/Symptoms
Larvae tend to feed at night or on cloudy days and hide in the soil or under foliage during the day. Newly hatched larvae are unable to chew entirely through the leaf surface resulting in a "window pane" appearance on the leaves. As the black cutworm larvae grow, their feeding damage becomes pinholes in the leaves and often complete defoliation of the leaves. Alternately, young variegated cutworm larvae feed on the terminal growth while older larvae feed near the ground. Once the larvae reach the "cutting" stage, they are 1/2 inch long and cut the stem at, or just below the soil surface. One large larvae may destroy several plants in one evening. The larvae will often pull the stem of the severed plant into their subterranean burrows. This type of injury is common during extended periods of dry weather.

Scouting Procedure and ET
Timely detection is critical if post-emergence insecticidal treatment is to be effective. Pheromone traps are useful for monitoring moth activity but do not correlate well with predictions of whether damage will occur as well as when or where damage may be expected. Shake five foot sections of two adjacent rows into the furrow and count the larvae on the soil surface. Divide the number of larvae counted by five. The resulting number is the number of worms per foot row. Repeat in several locations throughout the field since infestations may be restricted to certain areas. Prior to July 25, control measures are recommended if the cutworm and looper counts exceed four per row foot as a field average. After July 25, control measures are recommended if the cutworm and looper counts exceed eight per row foot as a field average.

Integrated Control
Non-Chemical Control
Natural Control: A number of braconid parasites and predaceous ground beetles help keep cutworm numbers down. Cutworms are most problematic in low, wet, grassy areas. Cutworms serve as prey to birds.
Cultural Control: Since female moths prefer to lay eggs in weedy situations, keeping weeds controlled will lessen the possibility of problems. Avoid planting susceptible crops in low wet areas or in rotations following sod. Coffee cans or other cylindrical barriers will provide adequate protection to small plantings.
Biological Control: Several species of tachinids, braconids and ichneumonids help reduce populations.

Chemical Control
Commercial: Broadcast applications of carbaryl, esfenvalerate, and permethrin are recommended for managing black cutworms. If only small, localized outbreaks occur, spot treatments are recommended. Refer to the product label for specific application instructions and precautions.
Homeowner: Apply Sevin bait if extensive foliage feeding observed.
Insecticide Resistance: None.

References
R. H. Davidson and W. F. Lyon (1987) Insect Pests 8th Ed. of Farm, Garden, and Home. John Wiley & Sons, New York 640 pp.

European Corn Borer

Scientific Name: *Ostrinia nubilalis*
Order: Lepidoptera
Family: Pyralidae

General Information
Biological Description:
Eggs are white, overlap like fish scales, and are deposited on the lower leaf surface of leaves and near the midvein. There can be as many as 30-40 eggs in each mass. As they develop, the eggs change to a creamy color. Just before hatching, the black heads of the larvae become visible inside each egg. This is referred to as the black-head stage and each egg reaching this stage usually hatches within 24 hours. Full grown larvae are 3/4-1 inch in length and grey to cream-colored with numerous dark spots covering the body. The pupae are brown, 3/4 inch long and cigar-shaped with segmentation evident on one-half of the body. The adults are nocturnal, straw-colored moths with a 1 inch wing span. Males are slightly smaller and distinctly darker than females.

Economic Importance:
The European Corn Borer is a sporadic pest of potatoes and is generally more severe in southern states. In years when the first generation of the European corn borer adults occurs early, the preferred egg-laying sites in corn are not yet available and ovipostition can be heavy in potatoes. Certain varieties are more susceptible to damage with Norgold, Norchip, and Norkota varieties being most affected.

Life Cycle:
The European corn borer overwinters as mature 5th instar larvae in corn stalks and stems of weedy hosts. Spring development

begins when temperatures exceed 50 degrees F. Pupation occurs in spring with the first moths emerging shortly thereafter. Peak emergence occurs at 600 degree days (base 50). Adult moths are nocturnal and spend most of their daylight hours in sheltered areas along field edges. Female moths lay egg masses in the evening. The eggs hatch in 3-7 days depending on the temperatures and young larvae feed on leaves and in the midrib of the leaves for 5-7 days (125 DD_{50}) before boring into stems. Boring usually begins with the second and third instars. The larvae pass through five instars and complete their feeding and development while boring inside stems. The earliest larvae to mature embark upon a 12 day pupal period within the stalk after which time the adult moths emerge. This begins the second generation. In northern areas, late-maturing larvae may go into diapause (a pause in development) and overwinter. Second generation moths peak in mid-summer when approximately 1700 DD_{50} have been reached and may lay eggs in potatoes or other crops. All mature 2nd generation larvae enter diapause in northern states and overwinter. In seasons with unusually warm spring and summer temperatures, some of the second generation larvae will pupate, emerge as moths and lay eggs for a late-season, third generation of larvae. These larvae do not have a chance to become fully grown before cold weather arrives and ultimately will perish. In southern states, three generations may occur.

European Corn Borer Development (DD base 50)

First Generation	Accumulated DD
First moth	375
First eggs	450
Peak moth flight	600
Larvae present	800-1000

Host Range:

Corn borers attack over 200 different kinds of plants including corn, vegetables, field crops, flowers and some common weeds. Serious damage may occur on sweet corn, peppers, snap beans and potatoes.

Environmental Factors:

Cool weather and drought delay spring insect development due to the desiccation of eggs and young larvae. Conversely, warm weather and moisture may accelerate insect development. Excessive heat and drought in spring may cause increased mortality of all stages. The number of eggs laid is affected by the availability of drinking water of which, dew is considered an important source. Heavy rainfall will decrease moth activity and drown newly-hatched larvae in whorls and leaf axils, or even wash them from the plant.

Damage/Symptoms:

When the European corn borer attacks potatoes, larvae can feed on foliage as well as inside stems. Larval feeding on the lower leaf surface results in small feeding scars when all of the leaf tissue except the transparent upper epidermis is eaten. Stems which sustain boring damage show an entry hole, 1/8 inch in diameter, typically surrounded by frass. Above the entry hole the stem may be wilted and the leaves flagged. Older, larger larvae create larger entry holes than do smaller larvae, and tissue around older entry holes is often discolored, whereas tissue is usually still healthy around recently-made holes. Most damage is caused by larvae which develop from eggs laid by moths flying in early summer. Secondary bacterial infection may invade the stems and cause stalk death.

Scouting Procedure/ET:

Egg mass counts are made to detect damaging levels of oviposition. The best procedure for determining when damaging levels of oviposition are likely is to operate a black light trap in the field and count trapped moths daily. Adult European corn borer moths congregate in dense weedy areas on field edges prior to egg laying. Traps should be operated in the grassy edge or corner of the field and should be far enough from buildings to avoid interference. Catches will vary with location, but when an increase in catch occurs on 3 consecutive nights the flight is severe enough to warrant treatment on susceptible crops. If moth flights are greater than 25 moths/trap/night anytime during the early summer flight, oviposition may be high enough to cause economically important levels of crop damage. By referring to light traps in other fields or areas, and by following statewide black light trap catches, growers can follow the general population and predict local areas more effectively.

Degree day accumulation may also be used to predict moth flights. Using a base temperature of 50^{o}F, peak flights will occur at 600 DD_{50} and 1700 DD_{50}. Action sites along field edges can be walked regularly to gauge the level of European corn borer populations close to an individual field. For the first generation, scouting should begin at 500DD_{50} and continue through 700DD_5 or until egg counts drop off. Sample for egg masses from the mid to lower portion of the plant by examining the lower leaf surface of 25 leaves per sample site. If greater than 4% of the leaves (one out of 25 leaves) are infested with eggs as a field average, control is recommended. Because Norgold, Norkota and Norchip varieties are particularly susceptible to damage, control is recommended if greater than 2% of the leaves are infested with egg masses.

Integrated Control

Non-Chemical Control:

Natural Control: Weather conditions greatly influence European corn borer survival, particularly during the egg stage and while young larvae are feeding on the leaves. Heavy rains wash the egg masses and young larvae off the plants and thus can greatly reduce borer numbers. In addition, very hot, dry weather causes desiccation of the eggs and young larvae. These climatic variables will kill 22-68% of freshly hatched larvae. Predators, parasites, and diseases also take their toll on European corn borer populations, however, there is no way to predict the impact of these factors.

Cultural Control: Plowing under crop stubble in the fall, thereby destroying overwintering larvae, has long been an effective method of reducing borer populations. This is especially important in nearby corn fields, where the majority of corn borers are

produced. European corn borer moths rest in weedy, grassy areas at field edges during the day and then fly into nearby crops to lay eggs at night. Cleaning up such areas around fields can reduce borer pressure. Certain varieties of potatoes are annually attacked by the European corn borer and may result in economic damage. Norgold, Norchip, and Norkota are attractive to oviposition, with Norgold and Norkota being especially susceptible to damage. Russet Burbank can sustain moderate to heavy damage without yield reduction, although quality may be affected.
Biological Control: *Bacillus thuringiensis* var. *Kurstaki* formulations can be effective if timed to target young larvae.

Chemical Control:

Insecticide Resistance: None.

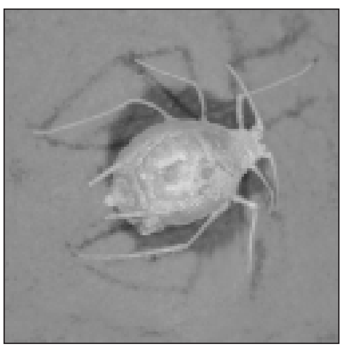
References:

C.L. Metcalf & R. L. Metcalf (1993) Destructive and Useful Insects, Their Habits and Control 4th Ed. McGraw-Hill Book Co., New York.

S. E. Rice Mahr, J. A. Wyman, E. B. Radcliffe, C. Hoy and D. W. Radsdale. 1995. Potato: Chapter 5 in Midwest Vegetable Insect Management. R. Foster and B. Flood Eds.

Green Peach Aphid

Scientific Name: *Myzus persicae*
Order: Homoptera
Family: Aphididae



General Information

Biological Description

Wingless forms are 1/8 inch in length, pear-shaped, soft-bodied, and commonly yellow-green in color but may be darker green or salmon. Winged forms are dark green on the head and thorax and have a dark patch on the abdomen. All forms have piercing/sucking mouthparts. When compared with the potato aphid, the green peach aphid has shorter legs and is broader. Green peach aphids are relatively immobile.

Economic Importance

The green peach aphid is the most serious pest of seed potato production due to its capacity to transmit potato leafroll virus and potato virus Y.

Life Cycle:

The green peach aphid overwinters as black, shiny eggs on the bark of *Prunus* spp: peach, plum, apricot, or cherry trees. Some aphids migrate into Wisconsin from overwintering sites in the southern states. Nymphs hatch at about the time *Prunus* spp. are in bloom. After 2-3 generations, winged forms are produced. The aphids then migrate to susceptible weed and crop plants and begin producing nymphs asexually. Infestations often begin in the field margins and many generations of wingless forms are produced during the summer. A single female can produce 50-100 live young with a complete generation requiring less than 10 days under ideal conditions. In response to adverse conditions, such as crowding, winged, asexual forms are produced and further dispersal occurs. In the fall, winged sexual forms are produced which mate and lay eggs on trees in the genus *Prunus*.

Host Range

The green peach aphid has an extremely wide host range which includes most vegetables, some fruit trees, ornamental shrubs, flowering plants, and weeds.

Environmental Factors

Heavy rain can rapidly decrease aphid populations as well as produce ideal conditions for the rapid spread of several fungal diseases which can rapidly reduce populations.

Damage/Symptoms

Green peach aphids possess extremely fine, needle-like, piercing mouthparts which are inserted between plant cells, and into the vascular tissue. Typically, this causes little direct morphological damage. When present in high numbers, enough sap may be extracted to cause plant wilting, particularly on hot, dry days. Eventual plant death may occur under extreme conditions and usually occurs in small circular patched which enlarge as aphids move. Excess sap is excreted as “honeydew” and falls on leaves, giving them a shiny appearance and sticky texture. Indirect damage caused by the transmission of plant viruses is extremely serious. The green peach aphid is an extremely efficient vector of many plant viruses and is known to transmit several important potato viruses including potato leafroll virus and potato virus Y. Winged forms of the aphid are generally more important in virus transmission.

Scouting Procedures/ET

Remove leaves from the mid to lower half of 25 potato plants per sample site. Count the total number of adult and nymphs. Sample at least five sites per 30 acres and add one sample site for each additional 20 acres. Since aphid species identification is difficult in the field, the following thresholds should be followed for all aphids.

Control measures are recommended when counts are as follows:

Fresh Market or Processing:

Early season—> 50 wingless aphids/25 leaves (all species)
After bloom—100 wingless aphids/25 leaves (all species)

Fresh Market or Processing Potatoes grown in Seed Production Areas:

7.5 green peach aphids/25 leaves
50 aphids of any species/25 leaves

Seed Potatoes

2.5 green peach aphids/25 leaves on virus susceptible varieties
5.0 potato aphids/25 leaves on virus-susceptible varieties
7.5 green peach aphids/25 leaves on virus resistant varieties

Katahdin, Kennebec, Norgold, Norland, Red Pontiac, and Shepody have been identified as having potato leafroll virus tolerance.

Integrated Control

Non-Chemical Control

Natural Control: Green peach aphids are susceptible to both biotic and abiotic mortality factors which can drastically affect population levels. Abiotic factors such as heavy rain can rapidly decrease populations or produce ideal conditions for the rapid spread of several fungal diseases which can reach epidemic proportions and decimate high populations very rapidly. Several predators including ladybird beetle larvae and adults, lacewing larvae and syrphid fly larvae are active particularly in conjunction with high aphid populations. Parasitic wasps are also common, leaving characteristic swollen hard shelled "aphid mummies" adhering to plant leaves. In general, however, the enormous reproductive potential of the green peach aphid is sufficient to override the effects of parasites and predators and economic levels of control cannot be expected.

Cultural Control: Due to the extremely large host range of this insect, cultural practices do not effectively reduce infestations. Geographic isolation in northern areas will delay onset of infestation and some states have been successful in removing overwintering sites.

Biological Control: Practices which conserve naturally-occurring natural enemies will help keep aphid populations down. However, because of the high reproductive potential of the aphids, sufficient control may not be achieved.

Chemical Control

Commercial: Systemic and foliar insecticides provide good control of the green peach aphid. Insecticides registered for systemic control of aphids on potatoes include Thimet, Disyston and Admire. Systemics are prophylactic and use should be dictated by several considerations such as risk of groundwater contamination, efficacy against target pest, efficacy against other potato pests, and persistence of control. Systemic insecticides are recommended for green peach aphid control in all seed potatoes. On table stock or processing potatoes, the use of systemic compounds is usually unnecessary and foliar sprays may be substituted. Systemic control of the green peach aphid is not normally required on short season processing or table stock potatoes. Thimet or Disyston may be applied at plant emergence on irrigated crops, or in the furrow at planting time on dry land. Do not use on muck soils. These materials should provide 70-80 days of protection, but scouting is recommended. Another option is to apply Admire in the furrow at planting time which will provide 80-100 days protection. Use this material only if there is no risk of groundwater contamination.

Foliar insecticides can also provide good control of the green peach aphid. Monitor provides the most effective green peach aphid control with Thiodan, Asana and Provado also providing protection. Please refer to the product label for specific application information and precautions.

Homeowner: Pyrethroids and insecticidal soaps are effective in controlling aphid populations in small garden situations.

Insecticide Resistance: Applications should only be made when thresholds are reached in order to minimize selection pressure. Chemical classes should be rotated when possible. Repeated use of methaimiophos should be avoided to preserve its effectiveness. Limit sprays of other classes

References

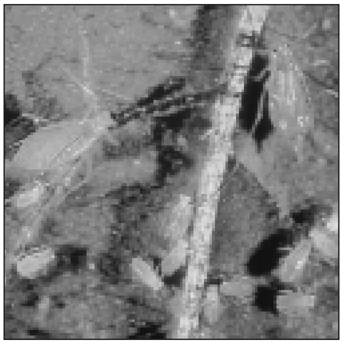
R.H. Davidson & W.F. Lyon (1979) Insect Pests of Farm, Garden, and Home. 7th Ed. John Wiley & Sons, New York. 596 pp.

C.L. Metcalf & R.L. Metcalf (1993) Destructive and Useful Insects, Their Habits and Control, 5th Ed. McGraw-Hill Book Co., New York.

S. E. Rice Mahr, J. A. Wyman, E. B. Radcliffe, C. Hoy and D. W. Ragsdale. 1995. Potato: Chapter 5 in Midwest Vegetable Insect Management. R. Foster and B. Flood Eds.

Potato Aphid

Scientific Name: *Macrosiphum euphorbiae*
Order: Homoptera
Family: Aphidae



General Information

Biological Description

Winged and wingless forms occur in high numbers on the lower leaf surfaces of terminal leaves and on young stems. Wingless forms are medium sized aphids, up to 1/8 inch long with elongated, smooth, soft, spindle-shaped bodies. Cornicles are long and parallel with the body. Antennae are held sideways and are longer than the body. Coloration varies from green to reddish-pink. Both color forms may be present at the same time. Winged forms are a pale green. When compared with the green peach aphid, potato aphids appear more slender and have longer legs. Wingless forms may drop from the plant if disturbed.

Economic Importance

The potato aphid is a sporadic pest of potatoes in Wisconsin and is primarily important as a vector of virus diseases, particularly potato virus Y.

Life Cycle

Potato aphids overwinter as black eggs on wild and cultivated roses. Eggs hatch in the spring and several generations are produced asexually on the succulent, developing tissue of the rose before winged forms of the aphid are produced. Winged aphids migrate to susceptible host plants in late June and July. On potatoes, aphids give birth to live young asexually and one female may produce 50 nymphs within a two week period. Aphid nymphs become mature in two weeks. The short generation time, along with the high numbers of offspring, result in rapidly exploding populations. As conditions become adverse or crowding occurs, the aphids disperse to new hosts. In late fall, winged forms return to roses, undergo sexual reproduction and lay overwintering eggs prior to frost.

Host Range

The potato aphid is primarily found on roses in the spring but migrate to a wide variety of plants including vegetables, flowers and weeds.

Environmental Factors

Heavy rain can rapidly decrease aphid populations as well as produce ideal conditions for the rapid spread of several fungal diseases.

Damage/Symptoms

Like other aphids, the potato aphid possesses a fine, needle-like stylet which is inserted between plant cells into the vascular tissue. Typically, this causes little direct injury to adjacent tissues. Extremely large populations may extract enough sap to cause leaf curling and wilting or eventual plant death under extreme conditions. Excess sap is excreted as honeydew and falls onto leaves, giving them a shiny appearance and sticky texture. Sooty mold fungi may grow on copious honeydew secretions. The potato aphid transmits some potato virus diseases but it is not as efficient a vector as the green peach aphid.

Scouting Procedure and ET

If potato aphids are found in the sweep net while sweeping for potato leafhoppers, then a leaf sample should be taken to get an accurate estimate of the potato aphid population present in the field. Remove the leaves from the terminal parts of 25 plants per sample site and count the total number of adult and nymphal potato aphids. Sample at least five sites per 30 acres and add one sample site for each additional 20 acres. Since aphid species vary in vector efficiency and may not be easily identifiable in the field, the following thresholds may be followed for all aphid species.

Fresh Market or Processing:
Early season—> 50 wingless aphids/25 leaves (all species)
After bloom—100 wingless aphids/25 leaves (all species)

Fresh Market or Processing Potatoes grown in Seed Production Areas:
7.5 green peach aphids/25 leaves
50 aphids of any species/25 leaves

Seed Potatoes
2.5 green peach aphids/25 leaves on virus susceptible varieties
5.0 potato aphids/25 leaves on virus-susceptible varieties
7.5 green peach aphids/25 leaves on virus resistant varieties
Katahdin, Kennebec, Norgold, Norland, Red Pontiac, and Shepody have been identified as having potato leafroll virus tolerance.

Integrated Control

Non-Chemical Control

Natural Control: Potato aphids are susceptible to both biotic and abiotic mortality factors which can drastically affect population levels. Abiotic factors such as heavy rain, can rapidly decrease populations or produce ideal conditions for the rapid spread of several fungal diseases which can reach epidemic proportions and decimate high populations very rapidly. Several predators including the ladybird beetle adult and larva, lacewing larvae, and syrphid fly larvae are active particularly in conjunction with high aphid populations. Parasitic wasps are also common, leaving characteristic, swollen, hard-shelled "aphid mummies" adhering to plant leaves. In general however, the enormous reproductive potential of the potato aphid is sufficient to override the effects of parasites and predators and economic levels of control cannot be expected.

Cultural Control: Due to the extremely large host range of this insect, cultural practices do not effectively reduce infestations. Geographic isolation in northern areas will delay the onset of the infestation.

Biological Control: Practices which conserve naturally-occurring natural enemies will help keep aphid populations down. However, because of the high reproductive potential of the aphids, sufficient control may not be achieved.

Chemical Control

Commercial: Systemic and foliar insecticides provide good control of the potato aphid. Insecticides registered for systemic control of aphids on potatoes include Thimet, Disyston and Admire. Systemics are prophylactic and use should be dictated by several considerations such as risk of groundwater contamination, efficacy against target pest, efficacy against other potato pests, and persistence of control. Systemic insecticides are recommended for potato aphid control in all seed potatoes. On table stock or processing potatoes, the use of systemic compounds is usually unnecessary and foliar sprays may be substituted. Systemic control of the potato aphid is not normally required on short season processing or table stock potatoes. Thimet and Disyston may be applied at plant emergence on irrigated crops, or in the furrow at planting time on dry land. Do not use phorate or disulfoton on muck soils. These materials should provide 70-80 days of protection, but scouting is recommended. Another option is to apply Admire in the furrow at planting time which will provide up to 100 days of protection.

Foliar insecticides can also provide good control of the potato aphid. Monitor provides the most effective followed by Thiodan, Provado, and Asana. Please refer to the product label for specific application information and precautions.

Homeowner: Insecticidal soaps are effective in controlling aphid populations in small garden situations.

Insecticide Resistance: Applications should only be made when thresholds are reached in order to minimize selection pressure. Chemical classes should be rotated when possible. Repeated use of Monitor should be avoided to preserve its effectiveness. Limit sprays of other classes of insecticides to two or less to avoid resistance build-up.

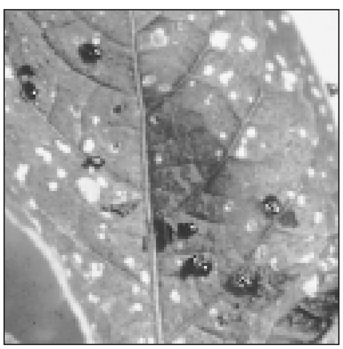
References

C. L. Metcalf and R L. Metcalf (1993) Destructive and Useful Insects, Their Habits and Control 5th Ed. McGraw-Hill Book Co., New York.

S. E. Rice Mahr, J. A. Wyman, E. B. Radcliffe, C. Hoy and D. W. Ragsdale. 1995. Potato: Chapter 5 in Midwest Vegetable Insect Management. R. Foster and B. Flood, Eds.

Potato Fleabeetle

Scientific Name: *Epitrix cucumeris*
Order: Coleoptera
Family: Chrysomelidae



General Information

Biological Description

Adults are small, shiny, black beetles with enlarged hind legs which allow them to jump from foliage when disturbed. Eggs are tiny, white and cigar-shaped. Larvae are delicate, and thread-like in appearance with white bodies and brown head capsules. Pupae are white and enclosed in earthen cells. Several other species of fleabeetle such as the tuber fleabeetle, western potato fleabeetle and the tobacco fleabeetle may be found in Wisconsin however, these are usually present in lower numbers.

Economic Importance

The potato fleabeetle can normally be found in Wisconsin potatoes but is rarely a serious pest.

Life Cycle

Potato fleabeetles overwinter as adults in the soil in fields in which they have matured. Beetles become active when temperatures reach 50 degrees F. and emerge in late May and June. They begin feeding on weeds or volunteer potato plants until the crop emerges. Adult fleabeetles lay eggs in the soil at the base of host plants. The eggs hatch in 7-14 days and larvae feed on the roots of the host plant until fully grown. After feeding for approximately two weeks, the larvae pupate in earthen cells for 11-13 days before emerging as adults. A complete life cycle takes 30-50 days and the second generation adults emerge in July - August.

Host Range

The host range of the potato fleabeetle is extremely large and includes many other vegetables such as cabbage, carrots, eggplant, beans, tomatoes, and peppers. Flowering plants, trees, and weeds are also included in this insect’s host range.

Environmental Factors

Potato fleabeetle populations can occasionally be very high, however, it is not known what conditions lead to these outbreaks.

Damage/Symptoms

Adult fleabeetles feed on both leaf surfaces but usually on the underside where they chew small, circular holes less than 1/8 inch, through the tissue to the upper cuticle. The circular holes give the plant a shotgun blast appearance which is characteristic of fleabeetle injury. Heavy feeding on young plants may reduce yields or even kill plants in severe cases. Larvae feed on the roots and tubers but do not cause economic injury.

Scouting Procedure and ET

Scout for adult fleabeetles by taking 25 sweeps per sample site with an insect sweep net. Sample at least five sites per 30 acres and add one sample site for each additional 20 acres. Control measures are recommended when adult counts exceed two per sweep.

Integrated Control

Non-Chemical Control

Natural Control: Little or no significant natural control exist for this insect.

Cultural Control: Clean cultivation and the elimination of early-season hosts will reduce populations. There have been reports of more severe damage on heavy soils than on sandy soils. Crop rotation will also reduce populations.

Biological Control: There are no commercially-available biological control agents which are effective in reducing populations of the potato fleabeetle.

Chemical Control

Commercial: Current pest management recommendations for potato fleabeetles on potatoes calls for insecticide treatment when populations exceed threshold levels. However, threshold levels are rarely exceeded in Wisconsin and foliar sprays should be coordinated with the need to control other, more damaging, pests. Guthion, Sevin, Furadan, Diazinon, Thiodan, Asana, Lannate, Monitor, Ambus, and Pounce are all registered for the control of the potato fleabeetle on potatoes. Refer to the product label for specific application instructions and precautions.

Homeowner: This insect is typically not a serious problem on small acreages of potatoes

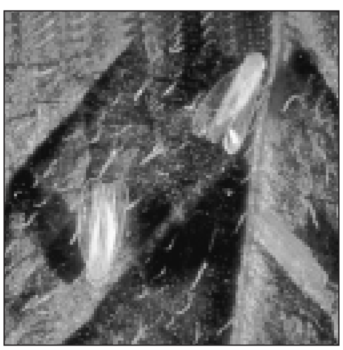
Insecticide Resistance: None.

References

C. L. Metcalf and R L. Metcalf (1993) destructive and Useful Insects, their Habits and Control 5th Ed. McGraw-Hill Book Co., New York.

Potato Leafhopper

Scientific Name: *Empoasca fabae*
Order: Homoptera
Family: Cicadellidae.



General Information

Biological Description:

Adults are small, wedge-shaped, pale green insects with whitish spots on the head and thorax. They have piercing/sucking mouthparts. Adults are extremely active; jumping, flying or crawling sideways or backwards when disturbed. Nymphs (immatures) are similar in appearance to the adults. They are yellow-green in color and do not have fully developed wings. Nymphs are less active but crawl rapidly, often seeking to regain the lower leaf surfaces when dislodged.

Economic Importance:

The potato leafhopper is a serious pest of potatoes in most midwestern production areas.

Life Cycle:

Potato leafhoppers do not survive northern states. Populations build up on legumes early in the year in isolated areas of the Gulf States and migrate northward in April and May on warm southerly winds. The first migrants, which are primarily females, reach midwestern states in early summer. Large influxes of migrants occur in June and early July causing populations to increase rapidly and seemingly ‘explode’ overnight. White eggs are laid on susceptible crops by insertion into stems or large leaf veins. Each female lays approximately 3 eggs/day and oviposition typically lasts about one month. Eggs hatch in 7-10 days. Nymphal development involves five successively larger instars and takes 12-15 days. Migrating adults die by July. First generation offspring mature in late July and the second generation matures in early September. There are normally only two generations per year in northern production areas with 3-4 in the south.

Host Range:

Potato leafhoppers feed on and may damage a wide range of host plants including alfalfa, apples, all types of beans, clover, dahlia, eggplant, potatoes, rhubarb, soybeans, strawberries, and other bedding plants and many weed species.

Environmental Factors:

Leafhopper injury develops most rapidly during hot, dry weather.

Damage/Symptoms:

Both nymphs and adults feed by inserting their piercing/sucking mouthparts into the vascular tissue of the plant and extracting sap. Damage is principally to the phloem cells which become blocked by salivary products during feeding, preventing translocation of photosynthetic products from the leaves. General symptoms include stunted plants, with chlorotic foliage which curls upward at the margins. Early symptoms include triangular, brownish spots at the leaflet tip or at the leaf margins near veinlets. Browning progresses inward from the margins and leaf margins become dry and brittle. Often, only a narrow strip of green tissue remains along the midveins. The burned appearance of the foliage is where the term “hopperburn” is derived. Symptoms of feeding injury begin on older foliage and move upward. Pre-mature death of untreated vines causes severe yield reduction. Damage may be more severe in hot, dry years. Nymphs are more injurious than adults. Yield loss may occur before obvious hopperburn symptoms develop and the level of yield loss is not directly related to hopperburn. Varieties Norland, Superior, Norgold, Norchip, and Atlantic are particularly susceptible to hopperburn.

Scouting Procedure/ET:

Scouting at regular intervals for both adults and nymphs is critical for effective potato leafhopper control. Take 25 sweeps with an insect sweep net per sample site. Nymphs are less mobile and are best scouted by leaf samples. Carefully turn over 25 leaves per sample site. Select the leaves from the middle portion of the plant. Use at least 5 sample sites per 30 acres and add one sample site for each additional 20 acres. If fewer than 0.5 addult/sweep are caught, do not treat unless nymph populations exceed 2.5/25 leaves. If 0.5 to 1.0 adults /sweep are noted, treat if adults persist at this level for 10-14 days or nymphs are present. If there are 1.0-1.5 adults/sweep, treat within 5-7 days or immediately if nymphs are present. Finally, if there are more than 1.5 adults/sweep, treat as soon as possible.

Integrated Control:

Non-Chemical Control:

Natural Control: No natural mortality factors of significance occur in potatoes although parasitic hymenopters (Mymaridae) are common when leafhopper populations are high. In humid conditions, entomopathogenic fungi may reduce populations. A rapid natural decline in population normally occurs in late summer..

Cultural Control: Healthy, vigorously growing vines will withstand damage more effectively than stressed plants. Irrigation and cultural practices which favor the crop are recommended. Infestations are likely to be more severe in crops planted adjacent to alfalfa, particularly after alfalfa is cut in mid-summer. The following varieties are listed in the order of decreasing susceptibility to potato leafhopper injury: Norland, Norchip, Atlantic, Superior, Goldrush, Snowden, Norgold Russet, Kennebec, Red Pontiac, Ranger Russett, Russet Norkota, Russet Burbank, Ontario, Red LaSoda. Thresholds may need to be adjusted based on the cultivar’s relative susceptibility to damage. Plants are also most susceptible to injury from emergence to completion of flowering.

Biological Control: None is available commercially.

Chemical Control:

Insecticide Resistance: None.

References:

R.H. Davidson & W.F. Lyon (1979) Insect Pests 7th Ed. of Farm, Garden, and Home. John Wiley & Sons, New York. 596 pp.

C.L. Metcalf & R.L. Metcalf (1993) Destructive and Useful Insects, Their Habits and Control. 4th Ed. McGraw-Hill Book Co., New York.

S. E. Rice Mahr, J. A. Wyman, E. B. Radcliffe, C. Hoy and D. W. Ragsdale. 1995. Potato: Chapter 5 in Midwest Vegetable Insect Management. R. Foster and B. Flood, Eds.

Tarnished Plant Bug

Scientific Name: *Lygus lineolaaris*
Order: Hemiptera
Family: Miridae

General Information

Biological Description

Adults 1/4 inch long and half as broad. They are dorsiventrally flattened with a small head. Coloration is variable, but generally brown with splotches of white, yellow, reddish-brown and black. There is a clear yellow triangle tipped with a smaller black triangle on the posterior end of the abdomen. Nymphs range in size from 1/25 inches to 3/16 inches long. Coloration is variable, ranging from mottled black and white bands on a dull green base to light green with black flecks. Nymphs also lack the wings which are characteristic on the adults.

Economic Importance

The tarnished plant bug is an occasional pest on potatoes.

Life Cycle

Tarnished plant bugs overwinter as adults under leaf mold, stones, tree bark, and among the stubble of clover and alfalfa. Adults begin to emerge in late April to early May. After feeding for a few weeks, they migrate to various herbaceous weeds, vegetables, and flowers where eggs are inserted into the stems, petioles, or midribs of leaves. Eggs hatch in about 10 days. There are five nymphal instars which require 20-30 days to complete. New generation adults begin to emerge in late June-July. There may be 2-3 generations per year with adults entering hibernation in October or November. Appreciable numbers of plant bugs are not seen on potatoes until mid-July.

Host Range

Tarnished plant bugs affect a wide host range including over 50 economic plants, as well as many weeds and grasses. They are often found on alfalfa, tobacco, beans, beet, cucumber, celery, chard, cabbage, cauliflower, turnip, potatoes, strawberries and other small fruits, tree fruit, and many flowering plants.

Environmental Conditions
Weedy fields or fields with a high degree of plant residue may increase the numbers of tarnished plant bugs.

Damage/Symptoms

The tarnished plant bug causes injury to potatoes by inserting their piercing-sucking mouthparts into the plant and removing sap. In addition, to the direct damage caused by feeding, the bug also injects a salivary secretion which is toxic to the plant. This toxin will produce small, circular, brown areas at the point of feeding. Feeding causes leaves to curl, new growth to wilt, and destruction of the flowers.

Scouting Procedure/ET

Tarnished plant bugs are most accurately sampled with an insect sweep net: take 25 sweeps/sample site with at least 10 sites/100 acres scattered throughout the field. When counts exceed one tarnished plant bug per sweep as a field average, control measures are recommended.

Integrated Control

Non-Chemical Control

Natural Control: A few insect predators do attack the tarnished plant bug, including a predaceous stink bug, an assassin bug, the big-eyed bug and a damsel bug. However, the amount of control provided by the predators is considered minimal.
Cultural Control: Because the tarnished plant bug overwinters in weeds, often those standing semi-erect during the winter, removal of weeds and favorite hibernating places may help in reduce its numbers.
Biological Control: None.

Chemical Control

Commercial: Several foliar insecticides are registered for control of plant bugs with Asana, Monitor, Ambush, and Pounce providing effective control. Soil-applied, systemic insecticides also provide effective control and populations will rarely exceed threshold levels in systemic-treated fields until mid to late season. Refer to the product label for specific application recommendations and precautions.
Homeowner: Sevin applied when populations reach 5 adults or 2 nymphs/plant will provide adequate control. Aphid populations may be increased with repeated Sevin applications.
Insecticide Resistance: None.

References:

R.H. Davidson & W.F. Lyon (1979) Insect Pests of Farm, Garden, and Home. 7th Ed. John Wiley & Sons, New York 596 pp.

C.L. Metcalf & R.L. Metcalf (1993) Destructive and Useful Insects, Their Habits and Control 5th Ed. McGraw-Hill Book Co., New York.

White Grub

Scientific Name: *Phyllophaga spp.*
Order: Coleoptera
Family: Scarabidae

General Information

Biological Description

Grubs are white-bodied, 1/2-1 1/2 inches, sluggish, C-shaped larvae with brown heads and six prominent brown legs. The hind part of body is smooth with body contents showing through skin. True white grubs are distinguished from similar larvae by 2 rows of minute hairs on the underside of the last segment. Adults are the common brown to black May or June beetles seen in the spring. There are several species of white grub in Wisconsin and all typically have a 3 year lifecycle. Their activity is primarily nocturnal.

Economic Importance

The grub-like larvae are occasional pests of Wisconsin potatoes, particularly following sod or in weedy fields.

Life Cycle

Most species have a three year life cycle in Wisconsin. Adults emerge and mate in late May to early June. Females search out grassy areas, burrow into the soil and deposit eggs. Eggs hatch in 2-3 weeks and grubs begin feeding on roots and underground plant parts. With the onset of cold weather, the grubs move beneath the frost line in the soil to overwinter. In late May, to early June the grubs migrate back to the surface soil horizons. It is during the second year that the most damage is done as larvae increase in size before they return to the subsoil layers to overwinter. In the third spring, the grubs return to the surface, feed for a short time and pupate. In late summer, adults emerge from the pupae but remain underground until the following spring. Peak adult flights occur in Wisconsin Every three years and historically have been noted in 1980, 1983, 1986, 1989, and 1992. The years following peak adult flight characteristically are peak larval damage years (1981, 1984, 1987, 1990, and 1993).

Host Range

Many species of crops are attacked. All vegetables, strawberries, roses, nursery stock, and most grass and grain crops are susceptible to grub damage.

Environmental Factors

White grubs injury is typically a problem in areas which were previously in sod.

Damage/Symptoms

In potatoes the grubs eat large, shallow, circular holes in the tubers. The above-ground portions of affected plants do not reveal the injury which is occurring below ground. As a result, serious tuber damage can occur before the grower realizes there is a grub problem. Damage is most severe in years following peak adult flights and is most pronounced in crops following sod or fields with grassy weeds.

Scouting Procedure/ET

No thresholds have been established. Grub populations in sod are estimated by turning sod over before September 15, and counting number of grubs/square yard. Populations above 3-4 grubs/ square yard are considered damaging.

Integrated Control

Non-Chemical Control

Natural Control: A parasitic fly - *Pyrogota* spp. parasitizes the grubs and may reduce populations. Birds are effective predators in freshly plowed fields.

Cultural Control: The first year after sod or grassy, weedy alfalfa will be the most damaging. Keeping grass weeds down in spring will prevent egg laying. Use rotation to avoid planting potatoes into infested fields following years of peak flights. Pasturing hogs on grub infested land will reduce the infestation.

Biological Control: Commercial preparations of milky spore disease are rarely effective.

Chemical Control

Commercial: Because white grubs are only an occasional pest in potatoes, chemical control is not recommended.

Homeowner: Apply diazinon (Spectracide) as a broadcast, preplant application and work into the top 6 inches of infested soil.

Insecticide Resistance: None.

References

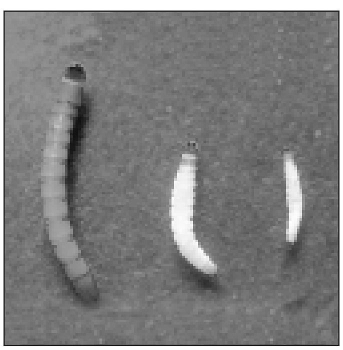
R.H. Davidson and W.F. Lyon (1979) Insect Pests 7th Ed. of Farm, Garden, and Home. John Wiley & Sons, New York. 596 pp.

C.L. Metcalf & R.L. Metcalf (1993) Destructive and Useful Insects, Their Habits and Control. 5th Ed. McGraw-Hill Book Co., New York. 1087 pp.

W.A. Sands and B.J. Landis. 1964. Potato Insects. USDA Handbook No. 264. 61 pp.

Wireworm

Scientific Name: Many species and genera
Order: Coleoptera
Family: Elateridae



General Information

Biological Description

The larvae of click beetles or wireworms are the damaging stage of this insect. They are thin yellow to reddish-brown, shiny, jointed worm-like larvae, 1/4 to 1 1/2 inch in length by 1/8 inch wide. Larvae are distinguished by ornamentation on the last segment. Adults are hard shelled, brown or black "streamlined" beetles which flip into the air with an audible click.

Economic Importance

Wireworms may be one of the more damaging pests of sweet corn.

Life Cycle

Wireworms have an extended life cycle, taking from 1-6 years. In Wisconsin, wireworms overwinter as either adults or larvae. Larvae live in the upper six inches of soil and feed on seeds and roots. They migrate only short distances. They are sensitive to moisture and may burrow deeply into the soil in dry conditions. Adults become active in the spring as they fly about searching for a site on which to lay eggs. Adult females may live 10-12 months, spending most of this time in the soil where they may lay up to 100 eggs. Eggs are laid in soil in grassy areas. This includes pastures, alfalfa, sod, and grassy weed infestations in row crops. Egg hatch occurs in several days to weeks. Tiny larvae immediately begin to feed on the roots of grasses , weeds and other crops. Because of the extended life cycle, larvae of some species will feed for two to three years before pupating. Adults that emerge from these pupae remain in the pupal chambers until the following spring.

Environmental Conditions

Wireworms tend to be most damaging 1-4 years after plowing up sod or in poorly drained lowlands, but they are not exclusive to those areas.

Host Range

Wireworms feed primarily on grasses, including corn and small grains as well as nearly all wild and cultivated grasses. Favored row crops include beans, beets, cabbage, carrot, lettuce, onions, peas, potato, radish, turnips, sweet potatoes, cucumber, and tomato. Asters, phlox, gladioli, and dahlias are some of the more commonly infested herbaceous ornamentals.

Damage/Symptoms

Damage is most likely to occur when infested pastures or alfalfa sod are plowed under and planted to row crops. Because of the long life cycle of wireworms, damage is possible two to three years after the field is taken out of sod. A second year of corn after sod may have more damage than the first year, perhaps because there are fewer grass roots to feed on. In sweet corn, damage to the ungerminated seed occurs when wireworms hollow out the seed, thus preventing germination. Later, they feed on below ground portions of the stem. They drill a hole into the stem and occasionally drill completely through it. Stems of small seedlings may be hollowed out up to the soil surface. By midsummer, soil temperatures have increased and soil moisture is reduced. At this time, wireworms and their damage often appear to disappear when in fact the wireworms have merely migrated deeper into the soil. Early indications of wireworm damage to sweet corn is the lack of germination which results from the destruction of the seed. Only a few plants may remain in a heavily infested area. The first few leaves of emerging seedlings will often show a pattern of holes which is caused by wireworms feeding through the leaves before they unfurl. Stem feeding caused plants to wilt and die, further adding to the "spotty" appearance of the field. On larger plants, only the center leaves may wilt. If these plant do not die, they are usually stunted and distorted, and will not produce a normal ear.

Scouting Procedure/ET

Scheduled scouting is not suggested. However, symptoms of wireworm activity may be observed during seedling stand counts or cutworm scouting. No thresholds have been developed. If wireworm damage is suspected, dig up several ungerminated seeds or damaged plants along with a 4-6 inch core of surrounding soil and check for wireworms in and around the roots, or in the underground portion of the stems. Larvae may be extracted from the soil by washing or the application of heat to soil surface in funnels.

Integrated Control

Non-Chemical Control

Natural Control: Several natural enemies have been described but they are not effective in reducing populations.
Cultural Control: Crop rotations which avoid susceptible crops and clean cultivation may reduce wireworm numbers. Some species thrive in poorly drained soil and can be reduced by adequate drainage. Clean summer fallowing of infested fields has been effective in some areas. Certain soil types (e.g. silt loams) are particularly susceptible.

Chemical Control

Commercial: Insecticides registered for the control of wireworms in sweet corn include chlorpyrifos, ethoprop, phorate, and terbufos. Insecticides should be applied in a 7 inch band or in the seed furrow. Refer to the product label for more information on specific application instructions and precautions. Application of insecticide after planting will not control wireworms.
Homeowner: Apply diazinon as broadcast, preplant applicationand work into top 6 inches of infested soil.
Insecticide Resistance: None.

References

R. H. Davidson and W. F. Lyon (1979) Insect Pests of Farm, Garden, and Home. 7th Ed. John Wiley & Sons, New York 596 pp.

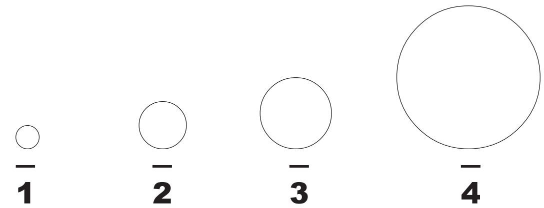
C. L. Metcalf and R. L. Metcalf (1993) Destructive and Useful Insects, their Habits and Control 5th Ed. McGraw-Hill Book Co., New York.

Instar Guide

Colorado Potato Beetle

Leptinostarsa decemlineata (say)

Determine into which circle the larva fits most completely without overlapping the borders. The number corresponding to that circle is the instar for that larva.



Variegated Cutworm

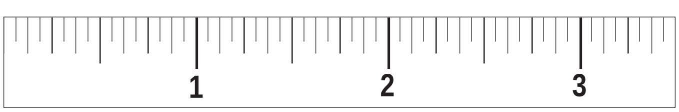
Peridroma saucia

Immobilize the larva by holding it with forceps, by placing it in alcohol, or by simply holding it tightly behind the head with the fingers. Be sure that the head is flat against the card and that you are looking at only the head capsule. Move the head down the scale until it just fits inside the figure. The number corresponding to that figure is the instar of that larva.

Variegated Cutworm head capsule gauge

Instar 3
Instar 4
Instar 5
Instar 6

Reference Scales for Other Larva



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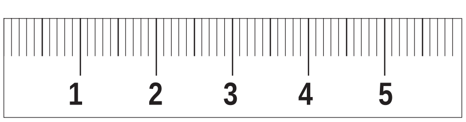


millimeters

Notes

Disease Profiles

Air Pollution Damage

Cause: Ozone and Peroxyacetyl Nitrate

General Information

Economic Importance

Air pollution has become an increasingly severe problem in our environment. The pollution of air causes appreciable injury to potatoes. Yield reduction due to early maturity or death of vines is often considerable. Incidence of the disease is not regular from year to year. The only successful way to control the problem is to plant varieties which tolerate the pollution.

Disease Cycle

None.

Host Range

A wide range of plants are susceptible to air pollution injury. Very susceptible plants include tobacco, potato, bean, tomato, spinach, and radish. Sweet corn and wheat are less susceptible. Strawberries, carrots and beets are resistant. Varietal differences have been observed in several crop species.

Environmental Factors

Air pollution damage to plants is becoming an increasingly important problem in the United States. Photochemical oxidants such as ozone and peroxyacetyl nitrate are formed by sunlight acting on hydrocarbons released in large amounts from automobile exhaust. Sulfur dioxide, a by-product released into the air from chemical companies, may also be a factor in the pollution damage on potatoes. Atmospheric ozone from extremely high altitudes causes plant injury after storms when air turbulence is sufficient to bring this ozone down from the troposphere. Sulfur dioxide injury begins as a light tan discoloration with necrosis between leaf veins.

Symptoms

Excess ozone causes an upward rolling of the leaves and a dark brown stippling of the upper leaf surfaces. Later, the brown lesions extend to the lower surface and lesions may coalesce. This symptom is most severe on older, mature leaves. Leaves also become bronzed, or yellowish, and may die but remain attached to the stem. Peroxyacetyl nitrate produces a silvering or glazing on the lower surfaces of affected leaves. The young, fully-expanded leaves show the most severe symptoms. In extreme cases, some injury may also be visible on the upper leaf surface. Plants affected by air pollutants mature early. The duration of time over which plants are exposed to pollutants influences the extent of injury.

Scouting Procedure/ET

Monitor potato fields weekly following a “W” shaped pattern across the field.

Integrated Control

Non-Chemical Control

Cultural Control: To avoid damage, potatoes should ideally be grown in areas that are not polluted with ozone or peroxyacetyl nitrate. This means in areas away from heavily traveled highways and away from industrial areas. Cultural practices which stimulate rapid early plant growth may permit plants to escape serious injury by presenting large foliage masses that can remove some toxicant from the surrounding air. Potatoes planted in low-lying areas with poor air circulation often show the most severe symptoms.

Resistant Varieties: Potato varieties which are fairly tolerant to pollution damage include: Alma, Belleisle, Hudson, Kennebec, Monona, Nampa, Russet Burbank, Sebago, Superior, and Targhe. Varieties with intermediate resistance include: Atlantic, Anoka, Haig, Katahdin, Norchip, Onaway, Red Pontiac, and Shurchip. Varieties which are severely affected are Centennial, Hi Plains, Norland, and Wischip.

Chemical Control

None.

Fungicide Resistance

None.

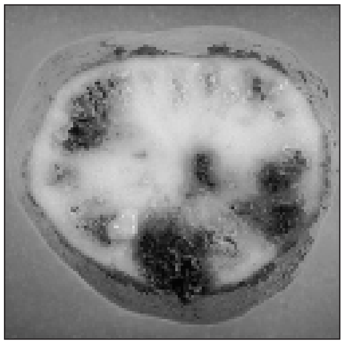
References

Compendium of Potato Diseases. 1981. American Phytopathological Society Press. St. Paul, MN. 125 pp.

Bacterial Ring Rot

Cause: *Corynebacterium sependonicum*

Type: Bacteria



General Information

Biological Description

Bacterial ring rot is caused by a gram positive bacterium. Cells are very small and form a characteristic bow-tie appearance when viewed on slides.

Economic Importance

Bacterial ring rot is a highly infectious disease of potatoes. It is readily spread by potato cutters, planters, harvesters, and even containers. A field is rejected for certified seed production if one diseased plant is found. Losses may be very high because tubers from infected plants may rot in the field or in storage.

Disease Cycle

The bacterium overwinters in tubers in storage or in tubers left in the ground and in bacterial exudates on baskets, bags, and equipment. The pathogen is not soilborne unless infected tubers survive over winter in the soil. The bacteria enters healthy plants through wounds or by contaminated knives during seed cutting. Once in the plant, the bacteria invade the xylem tissues.

Host Range

The bacteria which causes bacterial ring rot has been found in nature only on potato. However, it has been shown experimentally to be infectious on other solanaceous plants such as tomato and eggplant.

Environmental Factors

Bacterial ring rot develops rapidly in hot, dry weather. But when potatoes grow under a continuously cool environment, symptom development is delayed. The disease develops rapidly at soil temperatures of 65-70 degrees F. Temperatures above 70 degrees F delay symptom expression.

Symptoms

Symptoms associated with ring rot usually do not appear on plants until late in the growing season. Some plants can be infected without showing symptoms. Usually, areas between veins of the lower leaves of infected stems become pale yellow. The leaves may become pale green, mottled, and yellow, with an upward rolling of leaf margins. Leaf discoloration is accompanied by a progressive wilting. Eventually, the entire plant may die. When an infected stem is cut, the vascular tissues appear brown. A milky-white bacterial exudate can be squeezed from the base of an infected stem. This is called the ooze or squeeze test.

Infected tubers may have reddish areas near the eyes, or the skin may be swollen. Lightly infected tubers may appear healthy. When the tuber is cut across the stem end, a creamy yellow to light brown rot is visible in the vascular ring. The rot is crumbly to cheesy and odorless. If you squeeze a cut tuber, bacterial exudate oozes from the affected part of the ring.

Scouting Procedure/ET

Monitor potato fields weekly from mid-season until vine kill for early symptoms of this disease using a “W” shaped pattern across the field.

Integrated Control

Non-Chemical Control

Cultural Control: Control of ring rot is best achieved through the use of certified seed that is free from ring rot infection. It is extremely important to establish and maintain strict sanitation of all equipment. Discard bags that are dirty or suspected of having held ring rot-infected tubers. If ring rot has been present, clean out the storage area completely by destroying old tubers and debris before storing a new crop. It is desirable to plant small whole potatoes to avoid cutting seed pieces as knives contaminated with bacteria can transfer the disease. However, disinfecting cutter knives periodically during seed cutting will reduce the risk of spreading ring rot through the entire cut seed stock. Pick-type planters are more likely to spread the bacterium than assist or cup-feed planters. Practice a 2-3 year crop rotation.

Resistant Varieties: All potato cultivars currently being grown are susceptible to bacterial ring rot.

Chemical Control

Chemicals effective for disinfecting equipment and storage areas include quaternary ammonium compounds, chlorine calcium, sodium hypochlorite, Lysol 50% solution, phenol compounds 1-3% solution, and iodine.

Fungicide Resistance

None.

References

Stevenson, W. R. and S. A. Slack. Potato Ring Rot. 1983. University of Wisconsin-Extension Publication A3243.

Compendium of Potato Diseases. 1981. American Phytopathological Society Press. St. Paul, MN. 125 pp.

Bacterial Soft Rot

Common Name: Bacterial Stem Rot

Cause: *Erwinia carotovora* var. *carotovora*

Type: Bacterium

General Information

Biological Description

The bacteria which causes bacterial soft rot is a facultative anaerobe, gram-negative, motile rod.

Economic Importance

Bacterial soft rot is common wherever potatoes are grown. It is very widespread and often occurs in association with other stem and tuber diseases and injury. It may follow late blight, sunscald or freezing injury and may be serious in transit or storage if the temperature and humidity are notmaintained properly. It is common whenever a film of moisture persists on stems and tubers for extended periods.

Disease Cycle

The bacteria are primarily transmitted through infected tubers. Contamination of seed lots is common. High soil temperatures favor disease development with the optimum temperature range between 77-86°F. In the field, the bacterium can spread by splashing rain and irrigation, gaining entrance to stems through wounds.

Host Range

Erwinia carotovora var. *carotovora* has a wide host range which includes most fleshy vegetables. Those vegetables susceptible to the bacterium include: asparagus, bean, beet, carrot, celery, crucifers, cucurbits, lettuce, onion, pepper, potato, spinach and tomato.

Environmental Factors

The bacteria live in the soil and enter the tubers through wounds and natural openings such as lenticels; and stems through wounds. Frost-injured tubers are commonly invaded by soft-rotting bacteria. Bacterial soft rot is favored by rainy weather when potato tissues are moist and covered by a film of moisture and the lenticels enlarge, providing an entrance for the bacteria. The disease often spreads from infected to healthy tubers in storage.

Symptoms

When tubers are infected through the tuber lenticels, blisters formed on the affected tissues collapse to produce sunken areas 1/8 - 1/4 inch in diameter. If the tubers are infected through large bruises, the external lesions may appear light to dark brown and only slightly sunken. Affected tissues of tubers are typically white to cream-colored, soft, somewhat watery and slightly granular. A black margin separates diseased and healthy tissues. Later the infected tissue becomes gray-brown. A clear amber liquid often exudes from the decayed areas. Infected tubers break down partially or completely, and a watery rot develops. The decay may progress into either a wet-rot stage or it may dry up and leave chalky-white lesions. Soft rot affects tubers in storage, but seed pieces and newly-formed tubers can become infected. If secondary decay has begun, another bacterium, typically *Clostridium*, will be present. In such cases, the decay may become slimy and foul smelling. Stem infections appear as soft-rotted, often dark brown to black lesions several inches above the soil line. Infected tissues collapse and dry, leading to wilting of foliage or infected vines. Stem symptoms are differentiated from blackleg by observing the stem tissues at the soil line. In the case of blackleg, stem tissues at the soil line are black and decayed. This is generally not the case with bacterial stem rot.

Scouting Procedure/ET

None.

Integrated Control

Non-Chemical Control

Cultural: Planting certified seed is a primary defense against the development of bacterial soft rot. To prevent bacterial soft rot, handle the potato crop carefully during harvest to decrease the number of wounds, cuts, cracks or bruises. Harvest potatoes in dry weather if possible, to promote rapid drying and healing of wounds. Closely monitor irrigation prior to harvest to lower soil moisture levels. Tubers left in the soil for 7-10 days after vine kill will develop a skin which is less susceptible to wounding. Also, harvest tubers when soil temperatures are between 50-65°F to prevent bacterial development, should wounding occur. Avoid sunscald of tubers. Exposure of tubers to direct sunlight for as short a period as one hour increases their susceptibility to soft rot. Use spray jets for washing potatoes; never soak tubers in water for long periods. Do not reuse wash or rinse water. Dry tubers immediately after they are washed. Hot air dryers hasten drying. Do not pack tubers in air-tight containers, such as unperforated plastic bags. During the first week or ten days, store tubers at 60°F with adequate ventilation to promote rapid healing of wounds. Afterward, tubers may be stored at cooler temperatures. Control of bacterial stem rot includes controlling insects such as the European corn borer, avoiding stem injury by equipment, and careful irrigation to avoid maintaining a film of moisture on the vines.

Resistant Varieties: Cultivars seem to differ in susceptibility to bruising and the incidence of infection by the soft rot bacterium. A study at the UW-Madison demonstrated that potato cultivars with the highest levels of tuber calcium (Butte, Norgold Russet, and Russet Burbank) were consistently most resistant to bacterial soft rot on silt loam and loamy sand soils. The cultivars Rhinered, Superior, and Red La Soda were intermediate. Norland, Norchip, and Belchip, which had lower levels of tuber calcium, were most susceptible.

Chemical Control
The use of fixed copper sprays such as Kocide or Champion may help to reduce field spread and vine infection but are not a substitute for careful irrigation and irrigation scheduling. The application of calcium to field soil, and the accumulation of calcium by the tubers appears to reduce tuber susceptibility to bacterial soft rot.

Fungicide Resistance
None.

References

Hodgson, W. A., D. D. Pond and J. Munro. 1974. Diseases and pests of potatoes. Canada Department of Agriculture Publication 1492. 69pp.

O'Brien, M. J. and A. E. Rich. 1976. Potato diseases. USDA Agriculture Handbook No. 474. 79pp.

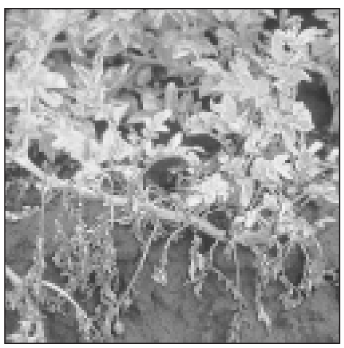
Rowe, R.C. ed. 1993. Potato Health Management. American Phytopathological Society, Inc. 178pp.

Black Dot Root Rot

Common Name: Black Dot

Cause: *Colletotrichum atramentarium*

Type: Fungus



General Information

Biological Description
Colletotrichum atramentarium belongs to the group of imperfect fungi. Reproduction occurs from conidia produced in acervuli on infected plant tissue. Cultures on potato dextrose agar may be yellow or pink in color as a result of the presence of numerous spores.

Economic Importance
Black dot is usually of minor importance but can be severe on early varieties of potato such as Superior. Severe rotting may cause a reduction in tuber size.

Disease Cycle
Black dot root rot overwinters as sclerotia on plant debris or tubers. Infection primarily occurs when plants are subject to stress brought on by environmental conditions or other pathogens.

Host Range
Black dot root rot may occur on tomato, pepper, eggplant, or potato.

Environmental Factors
Various environmental conditions have been implicated in infection of potato and severity of symptom development by *Colletotrichum atramentarium*. Primarily, black dot is associated with sandy soils, high temperatures and low nitrogen fertility. Root infection can occur at soil temperatures of 60-85 degrees F. in moist soil and the amount of infection which occurs is related to the number of microsclerotia present in the soil at the time of planting. Symptom expression is most severe when plantings are subjected to environmental stress. Stress factors include excessive rainfall, drought, freezing temperatures, and excessively high temperatures. The percentage of plant roots and stems infected by black dot gradually increases with plant age until almost all plants are infected late in the growing season. Increases in plant infection are most rapid in fields with high numbers of soil-borne microsclerotia.

Symptoms
The black fungal bodies on the stem, roots and tubers are responsible for the name of this disease. Symptoms first appear after flowering. They include a slight yellowing and rolling of the lower leaves. Later symptoms include reduced vine growth, wilting, and chlorosis of affected plants. These symptoms may mimic the symptoms of verticillium and fusarium. Stems of dead plants remain erect and leaves generally remain attached to the stem. Lower stems of dead plants are often covered with sclerotia especially at nodal regions. Roots and stolons of affected plants are often girdled by numerous small, brown lesions. Root and stolon lesions may resemble those of rhizoctonia. Remnants of the stolons up to one inch in length are commonly attached to small tubers produced on infected plants and sclerotia frequently occur on stolon remnants. Microsclerotia or other evidence of infection by this pathogen are usually not found on tuber surfaces or internal tuber tissues. In general, symptoms of black dot root rot are similar to symptoms caused by other soil-borne diseases such as Verticillium and Fusarium wilts.

Scouting Procedure/ET

Watch for symptoms of black dot root rot during weekly scouting for other pathogens and insect pests.

Integrated Control

Non-Chemical Control

Cultural Control: Continuous cropping of potatoes and related crops will result in a build-up of sclerotia in the soil and subsequent increase in disease. A three year rotation with non-susceptible crops such as corn, wheat, or mint will help to reduce the number of soil-borne microsclerotia to a safe level. The pathogen is frequently carried on potato tubers. Tuber-borne inoculum should be regarded as an important means of pathogen dissemination and early season plant infection. While the use of certified seed tubers does not insure the absence of the black dot root rot pathogen, certified seed stock is usually free of many other potato diseases. Infected potato vines provide sources of inoculum for subsequent plantings. Prompt removal of vines after harvest from home gardens will help to control this disease.

Resistant Varieties: Short season potato varieties with less vigorous vine types appear to be more susceptible than late season varieties with more vigorous vine types. Although all varieties are infected, Superior and Pontiac appear to be most susceptible, Norchip, Norland, Kennebec and Russet Burbank are more tolerant. Oneida is the most tolerant to infection by this pathogen.

Chemical Control

Soil fumigation with Vapam or Busan during the fall prior to planting will reduce soilborne inoculum.

Fungicide Resistance

None.

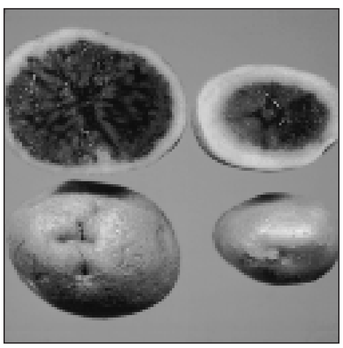
References

Compendium of Potato Diseases. 1981. American Phytopathological Society Press. St. Paul, MN. 125 pp.

Black Heart

Cause: Oxygen Stress

Type: Physiological



General Information

Biological Description

Black heart develops in tubers while they are growing, in transit, or in storage. It is a condition that results from lack of oxygen in the tissues of the tuber.

Economic Importance

This condition occurs when tubers are subjected to very high storage temperatures, poor storage ventilation or both.

Disease Cycle: None.

Host Range

This disease is only a problem on potatoes.

Environmental Factors

Black heart occurs at any temperature when the supply of oxygen available to internal tissues is used up faster than it can be supplied. The affected tissue is damaged and turns black. Conditions causing black heart can occur in the field when the soil is flooded or soil temperatures are extremely high; in storage when aeration is poor; in transit when tubers are overheated; or in prolonged storage near 32 degrees F. Black heart can be induced experimentally in nearly 100 percent of the tubers when they are held at 105-110 degrees for 24 hours.

Symptoms

Tubers affected with black heart generally show no external symptoms. In rare instances, moist areas that may be purple to black may appear on the surface. The common internal symptom is a dark discoloration: grey-purple or inky black. This discoloration is usually restricted to the heart of the tuber but may occasionally radiate to the skin. The discolored tissues generally are sharply set off from the healthy tissues, being firm and leathery if they have dried out. Affected tissues in advanced stages dry out, shrink and form cavities. If tubers are cut soon after injury, the exposed tissues are normal in color. Shortly after exposure to air, they turn pink, then grey, purplish, or brown and finally jet black.

Scouting Procedure/ET: None.

Integrated Control

Non-Chemical Control

Cultural Control: Avoid high temperature storage and provide good ventilation in storage areas. When potatoes are in transit, do not allow temperatures to go above 60-70 degrees F. To prevent oxygen shortages, do not store tubers in solid piles higher than 6 feet, unless aeration is provided. During harvest, remove tubers promptly from hot, light soils after the vines die. Remove tubers from the soil surface when dug during hot weather.

Resistant Varieties: Russet Burbank is reported to have some resistance to black heart, but most potato varieties from all growing areas are susceptible to this disorder.

Chemical Control: None.

Fungicide Resistance: None.

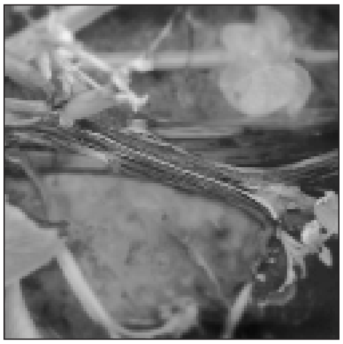
References

Compendium of Potato Diseases. 1981. American Phytopathological Society Press. St. Paul, MN. 125 pp.

Blackleg

Cause: *Erwinia carotovora* var. *carotovora*

Type: Bacterium



General Information

Biological Description

The bacteria which causes blackleg is a facultative, anaerobic, gram-negative, motile rod.

Economic Importance

Blackleg is a common bacterial disease wherever potatoes are grown. This disease can cause heavy losses through yield reduction and loss of tubers to rot in storage. Loss to pre-emergence seedpiece decay and pre-emergence shoot infection may also occur.

Disease Cycle

The pathogen may overwinter in the soil or in tubers associated with infected plant debris but does not appear to survive in the absence of host tissue. Infected seed pieces which are planted in the field, decay and release the bacteria into the soil. These bacteria may move with soil water to infect adjacent plants. The disease appears to also be spread in the field by various insects.

Host Range

Blackleg is an economically important problem only on potato.

Environmental Factors

Soil temperature and soil moisture markedly affect blackleg at low inoculum densities. Under dry conditions, only the pith in the top of the plant may show blackening, and aerial tubers may form on the stems. When sufficient moisture and cool temperatures prevail, the disease progresses rapidly and the entire plant wilts and dies. Affected tubers decay rapidly in wet soils.

Symptoms

The symptoms of chlorosis and severe rolling of the leaves can be recognized even when plants are only a few inches high. As the disease progresses, dark, inky black, and sometimes slimy lesions extend up the stems for some distance above the ground level. Dissection of infected stems show a black discoloration of the pith and vascular system. These lesions can also extend downward through the stolons to the tubers. Infected plants wilt and finally die as the lower stems are girdled with rotting lesions. An odor characteristic of rotting vegetation is associated with infected plants. When tubers are affected, decay usually begins at the stolon end of the tuber. The lesions produced by this rot are small and dark. Often only a small, circular black opening is visible on the tuber surface. Internal tuber tissue may show varying degrees of bacterial soft rot. Symptoms associated with pre-emergence seedpiece decay and pre-emergence shoot infection may be incited by the blackleg pathogen.

Scouting Procedure/ET

None.

Integrated Control

Non-Chemical Control

Cultural Control: The most effective measure for the control of blackleg is to plant clean, whole seed. Never use infected tubers for seed. If cut seed pieces are used, they are less likely to be entered by soil-borne bacteria if they are well suberized before being planted. Therefore, handle cut seed potatoes with care to promote rapid suberization, avoid heating, and prevent feeding by seed corn maggots which disseminate the bacterium. Periodic treatment of seed-cutting machinery and belts with a disinfectant will help to reduce the chances of pathogen transmission during the seed-cutting operation. Avoid planting cut seed pieces in soil that is cold or wet since these conditions favor infection. Irrigation scheduling should be practiced to prevent the development of anaerobic soils. Destroy old potatoes, cull piles, and potato refuse to prevent this debris from becoming a source of inoculum. Practice crop rotation.

Resistant Varieties: The cultivars Monona, Norgold, Russet Sebago, and Sebago are noted as being quite susceptible to blackleg.

Chemical Control

Machinery, warehouses, planters and seed cutters may be disinfected with a 5% calcium or sodium hypochlorite solution, or a 1-3% phenol solution.

Fungicide Resistance

None.

References

Compendium of Potato Diseases. 1981. American Phytopathological Society Press. St. Paul, MN. 125 pp.

Common Scab

Cause: *Streptomyces scabies*

Type: Bacterium

General Information

Biological Description

Streptomyces scabies is an aerobic organism which is classified as a bacterium but resembles a fungus. When grown in culture on potato dextrose agar, *S. scabies* produces colorless filaments. Conidia are barrel-shaped and borne on branched, filamentous conidiophores.

Economic Importance

Common scab is a serious soil-borne disease of potato tubers and is found throughout the world. Although the disease does not affect eating quality, surface lesions blemish tubers and reduce their commercial grade and market price. Scabbed tubers tend to shrink excessively during storage and are often invaded by secondary soft rotting organisms. Scab does not develop on tubers in storage.

Disease Cycle

The organism responsible for common scab overwinters in the soil. Infection occurs through natural openings in the plant such as the lenticels and stomata. Once the periderm develops on the tubers, this method of disease transmission no longer presents a problem, but rather, wounds serve as the site of infection.

Host Range

The organism that causes potato scab has a limited host range. Besides potatoes, it can infect turnips, sugar beets, garden beets, parsnips, rutabagas and radishes.

Environmental Factors

The scab-causing organism can live indefinitely in the soil. It is distributed on infected tubers by wind- and water-blown soil. It can survive passage through the digestive tract of animals and is distributed in manure. For this reason, manure applied to soil may favor scab infection. The organism persists for many years in fields that receive heavy applications of manure or in old barnyard sites. Scab is most common on potatoes grown in soils with a pH between 5.5 - 7.5 which have been in continuous potato production for several years. Scab rarely occurs in soils with a pH below 5.3 or above 8.0. Warm, dry soils and early season stress favor the development of the disease.

Symptoms

Common scab attacks tubers causing brownish spots that are small at first but later enlarge. The resulting lesions may be large, raised and corky or more frequently, they appear as small, russetted areas that occur only on the tuber surface. Both types of lesions may vary in size, shape and color. Lesions are usually grayish-white to dark tan, and are a little darker than normal healthy tissue. Thin-skinned potato varieties are more severely affected than varieties with a russetted surface, but surface scab affects russetted varieties as well. Scab should not be confused with enlarged lenticels that are found on tubers grown in excessively wet soils.

Scouting Procedure/ET

None.

Integrated Control

Non-Chemical Control

Cultural Control: The best control of common scab is through prevention. Always plant scab-free seed pieces on land that is free from scab. Practice long rotation of 3-5 years, preferably with legumes. Rotations should avoid potatoes, sugar beets, garden beets, radishes, and turnips in the rotational sequence. Soil pH should be tested before planting potatoes and adjusted to a pH of 5.2 to 5.8. Even tolerant varieties of potatoes may be attacked by scab when grown in slightly acid or alkaline soils. Choose proper fertilizers which help reduce the soil pH. Avoid the excessive use of lime, manure, and wood ashes. Maintain adequate soil moisture, especially during tuber initiation and early growth.

Resistant Varieties: The most effective way to control scab is to plant resistant varieties. Although no variety in commercial production is immune to common scab, several varieties are available with a relatively high tolerance to this disease. Some of the resistant varieties include: Butte, Caribe, Frontier Russet, Norland, Norchip, Onaway, Red Dale, Russian Banana, and Superior. Of the varieties commonly grown in Wisconsin, Superior and Russett Burbank have very good resistance; Norland and Norchip have good resistance; Kennebec and Katahdin have fair resistance.

Chemical Control

None.

Fungicide Resistance

None.

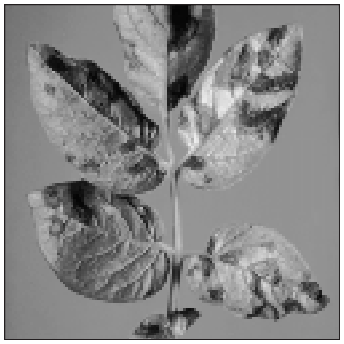
References

Compendium of Potato Diseases. 1981. American Phytopathological Society Press. St. Paul, MN. 125 pp.

Early Blight

Cause: *Alternaria solani*

Type: Fungus



General Information

Biological Description

Early blight is caused by *Alternaria*, a fungus which belongs to the group of fungi referred to as imperfect fungi. The fungus reproduces solely by asexual conidia.

Economic Importance

Early blight is a common foliage disease of potatoes. When leaf spots are numerous, foliage is prematurely killed and yield may be reduced. In years when the environmental conditions favor disease development, disease management costs may exceed 10% of the total cost of production.

Disease Cycle

Alternaria solani overwinters as spores and mycelium in plant refuse in the soil. In the spring, spores are released and spread to other plants by wind, rain and insects. The fungus penetrates the leaves through natural openings. As the infected plant grows, the infection spreads. Inoculum levels become high at the time of blossoming. Plants that lack vigor are predisposed to attack by this fungus. Plants with nutrient imbalances, virus infections, and insect damage have an increased risk of infection. Many cycles of early blight may occur within one season. Secondary infection occurs when foliar lesions begin to sporulate and spores are carried to nearby non-infected plants. Early blight may appear slightly earlier in the season than late blight, and is usually first observed in mid-summer but often causes its greatest damage late in the season if the weather is favorable.

Host Range

The early blight fungus causes serious diseases of tomato and eggplant as well as potato and can attack weeds such as hairy nightshade.

Environmental Factors

Moderate temperatures, high humidity, and prolonged leaf wetness from dews, rain, or irrigation, favor the development of early blight, but rain is not necessary for the development of the disease. Alternating periods of wet and dry weather tend to increase progression of the disease. The Potato Crop Management computer program uses environmental data to predict the occurrence of early blight and assists growers in the scheduling of fungicide applications.

Symptoms

Symptoms appear on the older foliage initially and progress upward in the plant. Leafspots are round, oval, or angular and are dark brown to black in color. These necrotic spots usually have concentric rings that produce a bull's-eye or target board effect. There is usually a narrow chlorotic zone around the lesion which fades to the normal green coloration further from the central lesion. As lesions enlarge and coalesce they are often delimited by the large leaf veins. Sometimes the spots coalesce, killing large areas and causing a leafroll that resembles tip burn. On stems, the fungus causes an elongated brown-black necrosis. Stem infection is less destructive than leaf infection. Early blight sometimes attacks the tuber. On tubers, the lesions are small, sunken, round or irregular in shape with slightly raised margins. The skin around the margin is slightly puckered. Affected tissue also develops a corky, brown dry rot. Tissue near the margin of the tuber lesion is yellow to green in color and water-soaked. Wounds are often necessary for tuber infection to occur.

Scouting Procedure/ET

Monitor fields weekly to determine the level of infection. Sample 5-10 sites per field following a 'W' pattern across the field.

Integrated Control

Non-Chemical Control

Cultural: Crop rotation is an important control measure. Fields infested with early blight the previous year are likely to have large overwintering populations of inoculum. Because the spores are wind-blown, however, crop rotation only delays the initial onset of the disease. Practices which reduce plant stress and which maintain healthy, vigorous plants reduces the severity of infection. Proper moisture and nutrition are also important. Avoid excessive irrigation and frequent irrigation that keeps foliage wet for prolonged periods. Provide adequate control of other diseases and insects to avoid predisposing the plants to infection. A 7-14 day delay between vine killing and digging reduces the risk of tuber infection. In small plots and gardens where the disease is serious, destroy the dead vines after harvest.

Resistant Varieties: Cultivars differ greatly in their susceptibility to early blight, but all cultivars currently grown in Wisconsin exhibit symptoms of early blight at some point during each growing season. Short season cultivars tend to be more susceptible than longer season cultivars. Within the following list of early and mid-season cultivars, susceptibility decreases further through the list with Norland being most susceptible and Castile lease susceptible: Norland, Redsen, Belrus, Norchip, Norgold Russet, Early Gem, Superior, Monona, LaChipper, Atlantic and Castile. Late season cultivars include Russet Burbank, Kennebec, Katahdin and Rosa with Rosa being the least susceptible. Very late cultivars such as Butte, Ontario and Nooksack have exhibited some tolerance to the early blight disease.

Chemical Control
Chemical protectant fungicide applications of maneb, mancozeb and chlorothalonil retard disease spread. Protectant materials must be applied to asymptomatic foliage before infection begins. Complete coverage and repeated applications, as new foliage emerges, are important. Use of disease management software helps growers analyze weather and crop information and determine when sprays are needed and the rates of application.

Fungicide Resistance. None.

References

Compendium of Potato Diseases. 1981. American Phytopathological Society Press. St. Paul, MN. 125pp.

Hodgson, W. A., D. D. Pond and J. Munro. 1974. Diseases and pests of potatoes. Canada Department of Agriculture Publication1492. 69pp.

O'Brien, M. J. and A. E. Rich. 1976. Potato diseases. USDA Agriculture Handbook No. 474. 79pp.

Pscheidt J.W. and W.R. Stevenson. 1986. College of Agricultural & Life Sciences Research Report. "Early Blight of Potato and Tomato: A Literature Review". University of Wisconsin Cooperative Extension Publication R3376. 17pp.

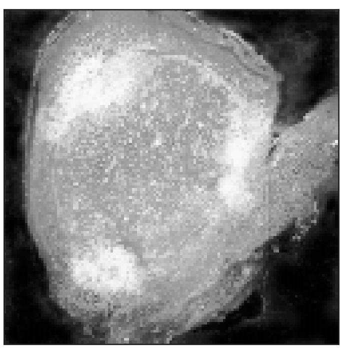
Rowe, R.C. ed. 1993. Potato Health Management. American Phytopathological Society, Inc. 178pp.

Early Dying

Common Name: Verticillium Wilt

Cause: *Verticillium albo-atrum*, *Verticillium dahliae*

Type: Fungus



General Information

Biological Description
There are two species of fungi responsible for early dying of potatoes. Both species are soil-borne but differ in the means in which they overwinter. *Verticillium albo-atrum* forms thickened mycelia within the infected plant tissue while *V. dahliae* produces small, hard, round black microsclerotia.

Economic Importance
Early dying is a disease that can cause serious losses in potatoes. Severe infections may reduce yield by 20% or more. Wilt severity and yield losses depend on the level of inoculum in the soil, prevailing weather conditions, and cultivar susceptibility.

Disease Cycle
Verticillium albo-atrum overwinters as mycelium in plant debris while V. dahliae survives as microsclerotia. Infection occurs through natural openings and wounds. Initial outbreaks are typically localized. Severity of each infection increases with each subsequent year potatoes are planted in the infested field. Dissemination occurs via infected seed and tubers.

Host Range
The Verticillium fungus that causes early dying disease can infect over 200 species of plants. Some of the vegetable crops affected include tomato, eggplant and okra as well as potato. Non-susceptible plants include corn and small grains.

Environmental Factors
The pathogen responsible for early dying can persist in the soil for two to seven years. Under conditions of low temperatures accompanied by sufficient soil moisture, typical wilt symptoms do not develop. Wet soils during the period of emergence to tuberization favor infection by the Verticillium fungus and dry, hot soils during tuber bulking favor symptom expression.

Symptoms
Symptoms can appear as early as flowering. The leaves of the infected plant wilt from the bottom of the plant upward. The wilted foliage becomes pale yellow and then brown. Sometimes only one stem is affected or possibly all but one stem may escape infection. Plants may either die very quickly or may succumb gradually. Often, on hot, sunny days, plants may wilt but regain turgor after sundown. Some curling and rolling of the leaflets and a tipburn may occur. Often, only the uppermost leaves remain green. The interior vascular tissue of the stems becomes yellow, and later, reddish brown. All of the fine feeder roots as well as the bark of the main taproot decay entirely. Tubers may exhibit a brown or black discoloration of the veins at the stem end.

Scouting Procedure/ET
None. *Refer to the section on Integrated Control for soil sampling recommendations.*

Integrated Control

Non-Chemical
Cultural: Soil sampling the fall before anticipated planting is useful in determining the level of inoculum present. Samples

should be obtained in the standard soil-sampling method which collects multiple samples along a W pattern across the field. If inoculum is >10 microsclerotia per cubic centimeter of soil, either the field should be bypassed for planting or the field should be fumigated to kill the Verticillium fungus.

Avoid planting infected seed pieces or planting clean seed pieces into infested soil. If the soil is infested, practice a three to four year rotation including a cereal crop or hay, but not strawberries, raspberries, tomatoes, peppers, eggplants or members of the cabbage family. Control weeds such a velvetleaf which may serve as a host to the fungus.

Resistant Cultivars

Cultivars differ widely in resistance to Verticillium wilt. Ontario is resistant. Sebago and Katahdin are slightly to moderately resistant. Most other cultivars are susceptible to the disease.

Chemical Control

Soil fumigation with metham-sodium to reduce nematode and verticillium populations is beneficial in reducing the spread of disease.

Fungicide Resistance: None.

References

Hodgson, W. A., D. D. Pond and J. Munro. 1974. Diseases and pests of potatoes. Canada Department of Agriculture Publication 1492. 69pp.

O'Brien, M. J. and A. E. Rich. 1976. Potato diseases. USDA Agriculture Handbook No. 474. 79pp.

Rowe, R.C. ed. 1993. Potato Health Management. American Phytopathological Society, Inc. 178pp.

Enlarged Lenticels

Cause: Excessive Moisture

Type: Environmental

General Information

Biological Description

The lenticels are natural pores of the potato tuber which are normally inconspicuous slits on the tuber surface. These lenticels become enlarged when potato tubers are allowed to remain in moist or wet conditions during harvest, storage, transit, or marketing.

Economic Importance

Enlarged lenticels detract from the appearance of the tubers and may serve as entry points for soft rot bacteria or other decay organisms.

Disease Cycle: None.

Host Range

Potato is the only susceptible host for this disease.

Environmental Factors

Enlarged lenticels may occur when tubers are harvested from heavy and water-saturated soils, when they are submerged too long in deep washing vats, or when they are packaged wet and held in moisture-proof containers for long periods. Lenticel enlargement also can occur when carbon dioxide concentrations in the soil increase to 5% even though adequate oxygen is present.

Symptoms

Enlarged lenticels rise about 1/16 inch from the surface and form numerous white protuberances over the tuber surface. If the tuber dries, the protuberances appear scab-like, are somewhat depressed, open and flesh-colored. Frequently the tissue becomes corky in appearance. Bacterial soft rot often accompanies the enlarged lenticel condition.

Scouting Procedure/ET: None.

Integrated Control

Non-Chemical Control

Cultural Control: Avoid planting potatoes in wet areas of the field. Remove tubers from the field promptly after harvest and store them under proper humidity-controlled conditions. Do not leave tubers in deep washing vats longer than necessary. Do not package tubers while wet and then only in ventilated bags. Avoid conditions that may result in the accumulation of carbon dioxide in soils. Avoid situations where tubers are covered with a film of moisture fo rprolonged periods.

Resistant Varieties: None.

Chemical Control: None.

Fungicide Resistance: None.

References

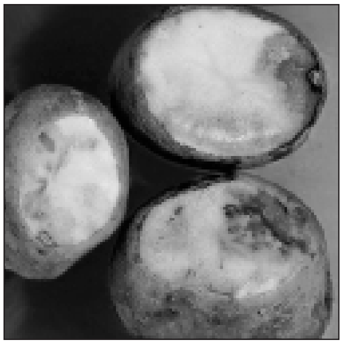
Compendium of Potato Diseases. 1981. American Phytopathological Society Press. St. Paul, MN. 125 pp.

Freezing Injury

Common Names: Frost Injury, Field Frost

Cause: Low Temperatures

Type: Environmental



General Information

Biological Description

Exposure of tubers to freezing temperatures leads to ice formation in tuber tissue and causes a variety of symptoms known as freezing injury. When tubers are exposed to temperatures that are below 40 degrees F, but not low enough to cause ice formation, starch is converted to sugar. As a result, the tubers develop a sweet taste. Tubers can be reconditioned by slowly warming them to temperatures of 50-55 degrees F.

Economic Importance

Freezing injury or frost necrosis can cause serious losses in areas where below-freezing temperatures are prevalent during harvesting, storing, or shipping of potatoes. The greatest danger exists in the northern states. Affected tubers do not show symptoms until thawed. Soft rot bacteria may enter affected tubers and cause them to rot. Injured potatoes should not be used for seed since they usually rot when planted. Most varieties subjected to low temperatures cannot be processed into potato chips satisfactorily.

Disease Cycle: None.

Host Range

All varieties of potato are susceptible to this disorder.

Environmental Factors

Freezing injury can occur before harvest where it is referred to as field frost. Freezing causes the formation of ice crystals within the tissue and results in tissue death. Frozen tubers scattered throughout a load when received on the market indicate that freezing happened in the field or during storage. Whereas frozen tubers along the floor and sidewalls of a truck or railroad car indicate transit freezing. This injury may occur when tubers are exposed to temperatures below 29 degrees F. However, potato varieties differ in their reaction to freezing. Long exposures to temperatures just below the freezing point can kill all tuber tissues. Short exposures just at the freezing point may kill only susceptible tissues. Tubers are less susceptible to low-temperature injury when the temperature drops rapidly than when there is a gradual temperature reduction.

Symptoms

Three types of necrotic pattern are common when tubers are exposed to very low temperatures. The first type, ring necrosis, consists of internal discoloration in and around the vascular ring. This type of injury is more common at the stem end. Net necrosis, the second symptom type, occurs as a net-like necrotic pattern scattered throughout the tuber within the vascular ring. Sometimes, darkened blotches are present with net necrosis. The third type, blotch necrosis, is the only condition which shows externally on the tuber. This condition is recognized by blotchy, irregular patches ranging in color from opaque gray or blue to sooty black. These patches occur anywhere in the tuber. Tubers affected with any type of freezing injury tend to shrivel and may become soft and watery. These symptoms only occur after the tubers are thawed or warmed.

Scouting Procedure/ET: None.

Integrated Control

Non-Chemical Control

Cultural Control: Avoid field frost by harvesting the crop and storing it before the ground freezes. Freezing injury to potatoes may be avoided by providing adequate protection from temperatures below 29-30 degrees F. In very cold climates or during very cold weather, supplemental heat must be applied during storage and in transit. During storage this heat must be distributed through ducts of a forced-air ventilation system to prevent freezing of tubers in some areas of the building. Adequate insulation must be present in buildings used for potato storage, particularly in northern areas.

Resistant Varieties: None.

Chemical Control: None.

Fungicide Resistance: None.

References

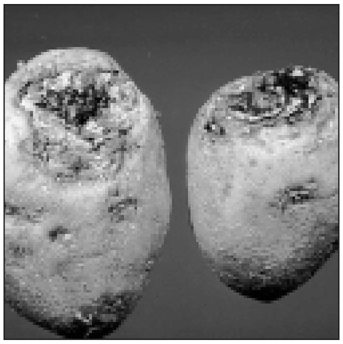
Compendium of Potato Diseases. 1981. American Phytopathological Society Press. St. Paul, MN. 125 pp.

Fusarium Dry Rot

Common Name: Fusarium Tuber Rot

Cause: *Fusarium solani* and *F. roseum*

Type: Fungus



General Information

Biological Description

Fusarium solani and *F. roseum* belong to the imperfect group of fungi.

Economic Importance

Fusarium tuber rots are widespread and cause heavy losses to potatoes in storage and markets. The disease reduces the market quality by discoloring the vascular system of the tubers, thus affecting the use of tubers for processing. Factors that contribute to Fusarium tuber rot include wounds, high storage temperature and humidity, and tuber infection with other diseases such as late blight, early blight and common scab.

Disease Cycle

Fusarium inoculum can remain in the soil for many years, however most infection is likely to be caused by surface contamination of the tubers. Infection occurs via wounds on the tuber which occur during the handling of seed pieces. As these infected seed pieces decay, inoculum infests the soil and later, daughter tubers.

Host Range

Fusarium spp. cause diseases of many vegetable crops in addition to potato. Jerusalem artichoke, carrots, cucumber, lettuce, onion, peppers, sweet potato, and tomato are among those vegetables which commonly are infected by Fusarium.

Environmental Factors

Fusarium species live in the soil or on plant debris. The first species of Fusarium described under 'Symptoms' below is more apt to be present in warm soils with temperatures between 78-89 degrees F. The second species is present in cooler soils with temperatures around 77 degrees F. The optimum soil temperature for infection of roots is 68-77 degrees F, with a minimum temperature of 53 degrees and maximum temperature of 86 degrees. There is no spread of the disease from infected to healthy tissues during storage, but the vascular discoloration may become more intense when tubers are stored at 50 degrees. Wet rot may occur when infected tubers are stored at 60-70 degrees F. High storage temperature and humidity favor disease development. At 40 degrees F, the disease is checked completely. Tuber dry rot is common on stored tubers which were harvested in fields subjected to long periods of excessively dry weather during the growing season since these tubers are likely to bruise at harvest.

Symptoms

Infected tubers usually develop a dry rot, but a moist rot may occur. The species of Fusarium may affect the type of symptoms produced. One species of Fusarium causes no external symptoms on potato but does cause an internal discoloration at the stem end of the tuber. The color of the vascular ring in the tuber varies from yellow or brown to black and may extend all the way through the tuber. Sometimes the vascular ring becomes hard and woody. Another species causes a brownish skin discoloration at the stem end, which later becomes sunken or wrinkled and may rot. A white fungal growth is often present on the wrinkled and rotted areas. The vascular ring becomes yellow, brown, or black and may be water-soaked. The discoloration may extend throughout the tuber. New tubers are affected more by the water rot than older tubers.

Scouting Procedure/ET: None.

Integrated Control

Non-Chemical Control

Cultural Control: If the soil is infested, practice a 3-4 year rotation including a cereal crop and hay, but not strawberries, raspberries, tomatoes, peppers, eggplants, or members of the cabbage family. Always plant certified, disease-free seed pieces. Follow good soil management, including use of proper irrigation practices. Harvest tubers from dead vines. Avoid harvest bruising, particularly on hot days. Store potatoes at 60-65 degrees F with moderate humidity for a few days to allow wounds to heal. Finally, store potatoes at about 38 - 45 degrees F depending on planned use of the tubers. To reduce losses from seed piece decay, plant whole seed tubers or handle cut seed pieces properly to hasten suberization. Do not store cut seedpieces longer than 10 days before planting.

Resistant Varieties: None.

Chemical Control

Thiabendazole (Mertect) may be used to mist unwashed tubers entering storage. Additional treatment may be made before shipping. Thiabendazole should not be used to treat seed potatoes after cutting.

Fungicide Resistance

Strains of Fusarium spp. have been detected that are resistant to thiabendazole. If you suspect the presence of these resistant strains, discontinue use of this fungicide. Isolated of the fungus should be checked for fungicide resistance.

References

Compendium of Potato Diseases. 1981. American Phytopathological Society Press. St. Paul, MN. 125 pp.

Fusarium Wilt

Cause: *Fusarium* spp.

Type: Fungus

General Information

Biological Description

There are at least four species of *Fusarium* which may cause Fusarium wilt. Spores produced by each of the species may be variable in morphology depending on the environment in which they are grown. All four species are readily isolated from infected tissue.

Economic Importance

Fungi in the genus *Fusarium* cause a variety of potato problems. Fusarium causes wilt, tuber rots, dry rot of tubers in storage, jelly end rot or soft rot of tubers, and seed piece decay.

Disease Cycle

Fusarium is a soilborne pathogen which enters the plant through the roots. The disease progresses through the root tissue until the xylem vessels become invaded, causing vascular plugging. Nearby phloem tissues may also be affected. Seed pieces which are infected with Fusarium may transmit the disease to the developing plant. Inoculum dissemination may occur via any means which transports soil.

Host Range

Fusarium species cause diseases of many vegetable crops in addition to potato. Asparagus, Jerusalem artichoke, carrot, cucumber, lettuce, onion, pepper, sweet potato, and tomato are among those vegetables which commonly are infected by Fusarium.

Environmental Factors

Early in the season, wet, cool soil favors infection by the Fusarium fungus which may cause the underground stems to rot and the plants to wilt and die. During wet weather, the wilt progresses more slowly and there is greater discoloration of the vascular system. In general, hot weather, wet soil, and rain or irrigation favor further development of the disease once infection has occurred. Cool, dry weather suppresses disease development.

Symptoms

The rate or type of symptom expression on potato is controlled by weather conditions and the species of Fusarium. Usually there is a yellowing of the lower leaves followed by rapid wilting, but sometimes plants show the effect of infection slowly and succumb gradually. The underground stems may decay and brown flecks appear in the stem pith. The woody stem tissues are yellow to brown from the base well into the top. A dry shredding of the tissue may be apparent. Discoloration is more marked at the nodes where the veins may turn dark brown. If soil moisture is high, the foliage may not wilt, but will show yellowing, rolling, and rosetting, sometimes accompanied by the development of aerial tubers. Affected leaves sometimes dry, droop, and often hang from the stem by the shriveled petioles. Vascular ring discoloration of roots and tubers may develop. Stem ends of infected tubers darken to a brown color.

Scouting Procedure/ET

Monitor potato fields weekly from mid season until vine kill following a "W" shaped pattern across the field.

Integrated Control

Non-Chemical Control

Cultural Control: Fusarium wilt is difficult to control and is often confused with another disease, Verticillium wilt. Plant disease-free seed pieces and handle cut seed pieces carefully to avoid bruising and allow cut tubers to suberize before planting if possible. To reduce losses from seed piece decay, plant small, whole seed potatoes. If soil is infested, practice a 3-4 year rotation including a cereal crop and hay, but not strawberries, raspberries, tomatoes, peppers, egg-plant, or members of the cabbage family. Follow good soil management, including the use of proper irrigation practices.

Resistant Varieties: Susceptibility varies between cultivars but differences are not well documented. The variety Shurchip is reported to be tolerant to Fusarium wilt while Superior is only slightly susceptible to the disease.

Chemical Control: None.

Fungicide Resistance: None.

References

Compendium of Potato Diseases. 1981. American Phytopathological Society Press. St. Paul, MN. 125 pp.

Gray Mold

Cause: *Botrytis cinerea*

Type: Fungus

General Information

Biological Description

The lesions caused by gray mold have grayish green or dusty brown clusters. Conidia are asexually produced spores which are produced in grape-like clusters on conidiophores. Hard, black sclerotia may be found on the surface of infected tissue. These sclerotia are the overwintering structures of the fungus.

Economic Importance

Gray mold is a common fungal disease with a wide host range. The disease is usually observed on potato vines in the field and tubers held in storage. In Wisconsin, it is typically not of economic importance.

Disease Cycle

The fungus overwinters as dark-colored sclerotia, on crop debris of potato and other hosts. In the spring, the resting bodies germinate to produce spores, which are disseminated by wind and rain.

Host Range

In addition to potatoes, gray mold also attacks the following vegetable crops: asparagus, beans, lima beans, broad beans, cabbage, carrots, celery, cucumber, eggplant, lettuce, onion, peppers, rhubarb, rutabaga, sunflower, squash, tomato, and turnips The various types of injury are leaf spots, stem cankers, fruit rots, tuber or root decay, and blossom blight.

Environmental Factors

When temperatures are cool and humidity is high, spores are released and infection begins once these spores come into contact with host tissue. Gray mold is often found in fields where an abundance of fertilizer is used. Thus the term "rich man's disease" is commonly applied to gray mold since the disease occurs when there is excessive and lush foliage. Abundant foliage creates a microenvironment high in humidity that is favorable to gray mold development.

Symptoms

Grey mold appears late in the season on the foliage, and may be mistaken for late blight. A grayish-green, wedge-shaped, spreading lesion with concentric rings appears on the leaves, often near an injury or a dried blossom. Lesions begin on the margins or tips of leaves. In severe infections, leaves are blighted and a soft gray rot attacks the stems. When vines are disturbed, spores billow from them like a cloud of dust. Gray mold normally attacks the lower, senescing leaves that have been weakened by shade or old age. The disease spreads through the plant via the petiole to the stem cortex.

Gray mold causes a flabby, slightly watery and odorless rot of tubers. The tuber surface may become wrinkled. Tuber infection is uncommon.

Scouting Procedure/ET

Monitor potato fields weekly late in the growing season. Follow a "W" shaped pattern across the field.

Integrated Control

Non-Chemical Control

Cultural Control: Gray mold is usually not a serious foliage disease, however, tuber infection may result in significant losses during storage. To reduce tuber rot, allow the tubers to dry before placing them in storage. Store tubers at 60-65 degrees F under high humidity for at least a week to 10 days. Avoid harvesting on cold days and do not store tubers at temperatures below 40 degrees F. Avoid overfertilization.

Resistant Varieties: None.

Chemical Control

Protectant fungicide applications with chlorothalonil fungicides will reduce the spread of foliage infection. Other fungicides such as maneb or mancozeb will offer some control but these are usually not as effective as chlorothalonil.

Fungicide Resistance: None.

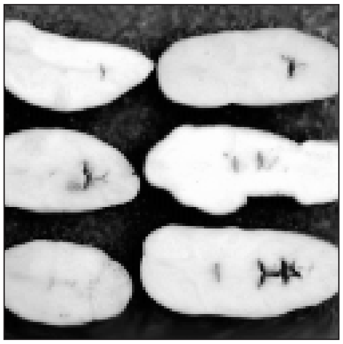
References

Compendium of Potato Diseases. 1981. American Phytopathological Society Press. St. Paul, MN. 125 pp.

Hollow Heart

Cause: Unfavorable growing conditions

Type: Environmental



General Information

Biological Description

Hollow heart is the name given to a conspicuous cavity at the center of a potato tuber.

Economic Importance

This disorder is prevalent in large, oversized tubers, and it can occur in potatoes during the growing season, in storage, or in transit. Normally, no external symptoms are noticeable, but the disorder can affect the marketability of the tubers.

Disease Cycle: None.

Host Range

All varieties of potato are susceptible to hollow heart.

Environmental Factors

Extremes in temperature and moisture can induce hollow heart. Growing conditions which favor rapid tuber enlargement increase the incidence of this disorder; particularly if they follow a period of moisture stress.

Symptoms

There ar no external symptoms of hollow heart. Initial symptoms appear as small, brown spots near the tuber centers. With time, these spots enlarge and become hollow. Internally, cavities form in the center of vary large tubers. These cavities may vary greatly in size and usually have cracks extending in many directions from the central cavity. The cavities are lined with pinkish tissue at first but this later turns brown. This disorder is thought to be due to conditions that cause very rapid growth. Some tubers that contain from one to many small cavities distributed throughout the flesh often with jet black tissue, have been exposed to extremes in temperature. Very high temperatures during growth, storage or transit, or chilling injury may cause this type of hollow heart.

Scouting Procedure/ET: None.

Integrated Control

Non-Chemical Control

Cultural Control: To control hollow heart, space seed pieces closely within the row and space rows close together. Close spacing prevents rapid and uneven growth of the tubers and tends to prevent internal splitting. Practice timely top vine killing to prevent excessive tuber growth. Harvest tubers as soon as vines are completely dead to reduce the time of exposure to high soil temperatures which may be present after vines are killed. Apply adequate amounts of fertilizer and irrigation water to the crop. During storage and transit, proper air circulation will prevent the buildup of excessively high temperatures. Storage of tubers at 40 degrees F and above will prevent chilling injury.

Resistant Varieties:

Avoid the use of varieties which are susceptible to hollow heart.

Chemical Control: None.

Fungicide Resistance: None.

References:

Compendium of Potato Diseases. 1981. American Phytopathological Society Press. St. Paul, MN. 125 pp.

Hopperburn

Cause: Leafhopper Feeding

Type: Insect

General Information

Biological Description

The leafhopper responsible for the disorder is the potato leafhopper (*Empoasca fabae*), a wedge-shaped, pale green, insect about 3 mm long with whitish spots on its head. It is a very active insect, flying, jumping or running backwards or sideways rapidly when disturbed. The injury is produced by the mechanical effects of leafhopper feeding and by the injection of a toxin into the plant. Hopperburn appears soon after feeding begins. This disorder can cause serious damage to potatoes in certain seasons.

Economic Importance

Hopperburn of potatoes occurs widely in the United States.

Disease Cycle

Please refer to the plant pest profile on the potato leafhopper for more information on this insect's life cycle.

Host Range

Potato leafhoppers prefer to feed on alfalfa, apples, all types of beans, celery, eggplant, potato, and nursery stock as well as other cultivated crops and weeds.

Environmental Factors

Hopperburn develops most rapidly during hot, dry weather.

Symptoms

Both nymphs and adults feed by inserting their piercing/sucking mouthparts into the vascular tissue of the plant and extracting sap. Damage is caused to both xylem and phloem tissues. Indirect damage results from the introduction of a toxin with the saliva during feeding. General symptoms include stunted plants with chlorotic foliage that curls upward at the margins. Early symptoms include triangular, brownish spots at the leaflet tip or at the leaf margins near veinlets. Browning progresses inward from the margins and leaf margins become dry and brittle. Often, only a narrow strip of green tissue remains along the midveins. The burned appearance of the foliage is where the term 'hopperburn' is derived. Symptoms of feeding injury begin on older foliage and move upward. Pre-mature death of untreated vines causes severe yield reduction. Damage may be more severe in hot, dry years. Nymphs are more injurious than adults.

Scouting Procedure/ET

Please refer to the plant pest profile on the potato leafhopper for scouting procedures and economic thresholds.

Integrated Control

Non-Chemical Control

Cultural: Follow good cultural practices and keep soil adequately moist. When the leafhopper population is high, it is difficult to produce a good crop unless the insect is controlled by insecticide sprays or dusts.

Resistant Varieties: Varieties of potato are being developed which are resistant to the potato leafhopper toxin.

Chemical Control

Commercial: Please refer to the plant pest profile on the potato leafhopper for more information on the chemical control of this insect.

Fungicide Resistance: None.

References

Sherf, A. F. & A. A. MacNab. 1986. Vegetable Diseases and Their Control. John Wiley & Sons, Inc. New York.

Internal Black Spot

Cause: Adverse Growing and Storage Conditions, Bruising

Type: Environmental

General Information

Biological Description

The cause of the disorder is unknown, but bruising and the environmental conditions during growth and storage influence the occurrence of internal black spot. Both result in the initiation of biochemical reactions which cause tissue blackening.

Economic Importance

Internal black spot is usually important only in tubers stored for several months, but freshly harvested tubers may also be severely affected.

Disease Cycle: None.

Host Range

This problem is specific to potatoes.

Environmental Factors

Susceptibility of potato varieties to internal black spot varies with the season. Therefore, the environmental conditions under which plants grow in the field have some role in the development of the disorder. The amount of water in the tuber at harvest somewhat affects the degree of resistance of the potato. Apparently water helps prevent bruising, which is a major factor in internal black spot. Potatoes grown under dry conditions are more likely to develop blackspot. Higher holding temperatures tend to predispose potatoes in storage to the disorder. The effects of soil fertilization on the development of internal black spot are conflicting and inconsistent at this time.

Symptoms

Internal black spot is characterized by bluish, brown, or black spots that occur in the tuber flesh from the vascular ring outward. Occasionally, deeper tissues are affected. These spots generally occur near the tuber stem end and usually are on the shoulders that get bumped easily. The spots develop from a slight jolt or bruise during handling. Internally, when the spots first begin to develop, they are pink, then red, and after 12-18 hours, they turn blackish. The absence of periderm in these lesions will help distinguish black spot from other similar disorders. The spots are usually not visible on the outside of the tuber, even after washing. However, very severe cases of internal black spot can be seen on the tuber surface as sunken spots with blackened tissue. These spots are sharply delimited from normal tissue.

Scouting Procedure/ET: None.

Integrated Control

Non-Chemical Control

Cultural Control: Irrigate dry soil to maintain tuber turgor before harvest. Harvest tubers at maturity. Handle tubers carefully to avoid bruising and moisture loss during storage. After harvest, tubers should be carefully cured and stored at temperatures compatible with future marketing options. Gradually warm tubers to 50-55 degrees F before grading and packing. Avoid a rapid flow of dry air that may cause excessive loss of tuber moisture. The prime measure for control of internal black spot is to handle the tubers carefully during harvesting, grading, and packing operations to avoid bruising.

Resistant Varieties: Pontiac is apparently resistant to internal black spot while most other varieties are susceptible. Varieties with high dry matter are particularly susceptible to this disorder.

Chemical Control: None.

Fungicide Resistance: None.

References

Compendium of Potato Diseases. 1981. American Phytopathological Society Press. St. Paul, MN. 125 pp. 728pp.

Jelly End Rot

Common Name: Glassy End Rot

Cause: Unfavorable Growing Conditions

Type: Environmental

General Information

Biological Description

Jelly end rot is a common disorder which affects either the stem end or malformed knobs of potatoes. It primarily occurs on abnormally-shaped tubers such as spindle-shaped, knobby, or dumbbell-shaped tubers. The disorder is caused by the fluctuation of unfavorable weather conditions which are not suitable for steady tuber growth.

Economic Importance

Jelly end rot may result in serious losses during harvest, storage, transit, and marketing. Losses are due to a soft watery breakdown of tissue.

Disease Cycle

There are no pathogenic organisms associated with jelly end rot, however, secondary bacteria may become present later in the disease.

Host Range

Jelly end rot is common to all potato varieties.

Environmental Factors

Jelly end rot is caused by environmental conditions which interfere with the normal enlargement of tubers, especially at the stem end. Weather conditions which inhibit the development of young tubers and later cause rapid tuber growth induce the disorder. Very high temperatures, and drought followed by heavy rain, and vine defoliation may promote jelly end rot. Fluctuations in water supply during the season may also be responsible for the disorder. Jelly end rot is most common when a hot, dry summer is followed by a cool, rainy fall. The condition does not spread in storage but subsequent secondary soft rot infections may be spread to other tubers.

Symptoms

Jelly end rot always occurs at the stem end of tubers or on knobs and sometimes shows no external symptoms. When external symptoms occur, the stem end is soft and the skin wrinkled. The rotted flesh varies from colorless, to straw color, to various shades of brown or black. At first the flesh is jelly-like and watery and is set off sharply from normal tissue. As the tuber ages, the water evaporates leaving a dried, shriveled clump of tissue collapsed at the stem end. This rot occurs most often on long, narrow, or pointed tubers and extends 1-2 inches from the stem end. Even round tubers that have secondary growth (knobby, dumbbell, or bottleneck-shaped tubers) may also develop jelly end rot.

Scouting Procedure/ET

None.

Integrated Control

Non-Chemical Control

Cultural Control: Irrigation started early in the growing season and continued as needed until near harvest will help reduce the amount of rot. If irrigation is impractical, follow cultural practices that help retain soil moisture, such as the adequate spacing of rows, proper hilling, and cultivation. Plant early maturing varieties or plant regular season varieties late so that crops are not at the critical stages of tuber production when severe weather fluctuations occur. No postharvest control is known. Do not store potatoes with a high percentage of tubers affected by jelly end rot with other tubers.

Resistant Varieties: Netted Gem is particularly susceptible to jelly end rot.

Chemical Control

None.

Fungicide Resistance

None.

References

Compendium of Potato Diseases. 1981. American Phytopathological Society Press. St. Paul, MN. 125pp.

Late Blight

Cause: *Phytophthora infestans*

Type: Fungus

General Information

Biological Description

The late blight fungus is found throughout the world and has been responsible for periodic epidemics of late blight when weather conditions favor infection and spread. There are two mating types of the late blight fungus, A1 and A2. Both of these mating types are present in Mexico and until recently, only the A1 mating type was distributed worldwide. All this changed beginning in 1984 when the A2 mating type was reported in Europe. Since 1984, strains of the A2 mating type have become widely distributed and it wasn't long before the A2 mating type was observed in the U.S. and Canada. The presence of both mating types in a specific area has important implications in control. When only one mating type is present in an area, the fungus reproduces asexually (sporangia) and survives only in association with living host tissue (living foliage, stems, tubers, fruit (tomatoes)). When both mating types are present, however, sexual reproduction is possible leading to the development of oospores with thick walls and the capability of surviving overwinter in the soil in the absence of living host tissue. Oospores are produced in large numbers in culture, but may be less common in nature. Oospores germinate by producing a sporangium, but can also germinate by producing a germ tube that grows directly into mycelium. Progeny of the A1 + A2 mating are either A1 or A2 mating types. Recently, oospores were observed on potato tissues in Europe. We have much to learn about oospores in nature. Data are lacking on the length of time oospores can survive in our harsh environment and what role oospores play in initiating plant infections in subsequent cropping years.

In addition to the A1 and A2 mating types, there are several genotypes of each mating type. Dr. Bill Fry (Cornell University) has tracked both the mating types and genotypes as the populations of the late blight fungus become increasingly complex. The current clonal structure of the pathogen populations in the U.S. allows researchers to identify specific genotypes and to track their spread. There are currently only four genotypes that are widely distributed in the U.S. and parts of Canada until recently. This genotype was the predominant form in Wisconsin during 1993 and appeared in some Wisconsin fields in 1994. US-1 is still susceptible to Ridomil application and in fact, still responds to Ridomil treatment in grower fields. The US-6 genotype appeared in the U.S. in the late 1970's/ early 1980's. This genotype belongs to the A1 mating type and is resistant to Ridomil fungicide. We have not observed US-6 in Wisconsin. The US-7 and US-8 genotypes appeared in the U.S. in the early 1990's. Both belong to the A2 mating type and both are resistant to Ridomil fungicide. Two fields in northwest Wisconsin were infected with the US-7 genotype in 1993, but this genotype did not reappear during 1994. The US-8 genotype caused damage in Florida and eastern U.S. and Canada during 1993. During 1994, this genotype was identified as far west as Wisconsin, North Dakota and Manitoba. The US-8 genotype is very aggressive and appears capable of long distance transport via storms. This genotype is very difficult to control with protectant fungicides and it is resistant to Ridomil fungicide.

Economic Importance

Late blight can be a very serious disease on potatoes particularly where the weather is consistently cool and rainy in late summer and fall. In Wisconsin, late blight occurs about once in six years, but when it does occur, losses can be significant. The disease has been widespread and serious in 1978, 79, 80, 93 and in 1994, late blight caused losses to the Wisconsin potato industry exceeding $9 million.

Disease Cycle

The pathogen survives during winter months in association with potato tubers. Tubers that overwinter in the soil, tubers dumped in cull piles from warehouses in the spring and infected seed slivers serve as sources of inoculum for neighboring fields. The late blight fungus grows in and on plants which develop from infected tubers. After crop emergence, the fungus infects developing sprouts. Primary inoculum is produced under moist conditions and the disease is disseminated further by wind or water or human activity. Sporangia of the fungus are formed at a relative humidity of 91-100% and a temperature of 37-79 degreesF with an optimum temperature of 64-72 degrees F. Zoospores germinate most rapidly at 54-59 degreesF and rapid germ tube formation occurs at 70-75 degreesF. Temperatures above 86 degrees F are unfavorable to late blight development.

Host Range

The late blight fungus primarily attacks only tomato and potato but eggplant and other solanaceous plants such as hairy and black nightshade are occasionally infected.

Environmental Factors

The pathogen is most active during periods of cool moist weather. Cool nights with temperatures of 50-60 degreesF, and warm daytime temperatures of 60-70 degrees F are ideal for late blight development. Fog, rain or heavy dew for four to five consecutive days will also favor disease development.

Symptoms

Symptoms of late blight appears on leaves, stems and tubers. Leaf symptoms appear as pale green, water-soaked spots that often begin at the edges of leaves or leaf tips where water from rain and dew accumulates. The circular or irregularly shaped lesions are often surrounded by a pale yellow to yellow green border that blends into healthy green tissue. The lesions enlarge rapidly and killed tissues turn brown to black. It is not uncommon for leaf lesions to expand in diameter by 1/4" to 1/2"per day until the whole leaflet is killed. Often during periods of ideal temperature 64-72 degrees F and abundant moisture, there may be multiple lesions per leaflet. When relative humidity is above 90% and leaves are wet from rain or dew, leaf lesions are bordered by a cottonlike white mold on the lower leaf surface. The mold consists of masses of sporangia (spores) and the structures that bear the sporangia. Wind, rain, machinery, workers, wildlife, etc. can dislodge the sporangia and carry them to other plant parts and neighboring plants. There was evidence in 1994 that sporangia were being transported via storms as far as 25 or more miles, making late blight a community as well as a regional problem. During high temperatures and low humidity, leaf lesions dry and infected leaves die and fall from the plants. Stems and petioles may also be infected by the late blight fungus. Infected stems and petioles turn brown to black and entire vines may be killed, depending on the location of the lesions. Stem and petiole infections may ve covered with white masses of sporangia during wet weather. Stem and petiole infections may be more prevalent in some fields than leaf lesions and in fact, leaf lesions were rare in some fields while tubers harvested in these fields had a high incidence of tuber blight. Because of a similarity in appearance to bacterial stem rot, Botrytis vine rot and even blackleg diseases, the stem and petiole lesions may be overlooked or misidentified in the field. It should also be noted that in addition to symptoms appearing on potato, tomato and a weed, hairy nightshade, are also susceptible to the late blight fungus. Tomato foliage, stems and fruit are susceptible to the late blight fungus, while symptoms on hairy nightshade seem to be confined to the leaves.

Tuber infection occurs when sporangia, washed into the soil via cracks or crevices in the hill, come in contact with tubers. Moisture in the hill provides an ideal environment for tuber infection. Varieties with shallow-set tubers and plantings where there is significant hill erosion or cracking experience the greatest risk of tuber infection. Tubers may also come in contact with sporangia when green infected vines are present at harvest. Tuber infection results in a coppery brown dry rot that spreads irregularly from the tuber surface through the outer 1/8" to 1/2" of the tuber tissues. The boundary between healthy and infected tissue is not well defined and the depth of infection may vary from one variety to another. Later in storage, tuber lesions become sunken as water is lost from infected areas. Tubers infected with the late blight fungus are often infected with soft rotting bacteria and fungi, often leading to a slimy and smelly breakdown of stored tubers. Infected tubers surviving in the field as volunteers or in cull piles serve as overwintering sites for the late blight fungus. Potato cultivars differ in susceptibility to late blight infection. The Ranger Russet variety is especially susceptible to tuber infection and during 1994, up to 40% tuber infection at harvest was observed in some fields.

Scouting Procedure/ET

Monitor potato fields weekly for early symptoms of disease. Examine 5-10 sites per field following a ‘W’ pattern across the field. As favorable conditions develop, scouting frequency should be increased. The use of disease prediction programs will benefit commercial growers in their monitoring and management practices.

Integrated Control

Non-Chemical Control

Cultural: Cultural control measures include the following: 1) eliminate all potato cull piles, 2) destroy volunteer potato plants that grow from overwintered tubers, 3) plant only disease-free seed that has passed a seed certification program. Certified tubers are identified by appropriate labels that indicate they were grown under supervision and inspected for various disease. Several late blight forecasting systems have been developed. These include the Hyre system (temperature and rainfall), the Wallin system (temperature and humidity), and the Blitecast system that integrates both systems into a computer program. The Potato Crop Management Program (PCM) uses the Blitecast system to forecast disease development on the basis of temperature, relative humidity and rainfall. Forecasting systems are crucial in determining whether fungicide applications may be necessary to reduce crop loss to late blight. In addition, maintain adequate tuber coverage with soil to prevent tuber infection. Allow two weeks between vine kill and harvest. This will reduce the amount of inoculum present on the foliage as well as improve identification of infected tubers before storage.

Resistant Varieties: No cultivars are immune to late blight, but several cultivars possess some resistance to the common Race O as well as some of the other races of the fungus. Moderately resistant varieties include Rosa, Kennebec, Sebago, and Nooksack. Moderately susceptible varieties are Russett Burbank, Atlantic, and Katahdin. Susceptible varieties include Norchip, Monona, Belrus, Belchip, Superior, Norland, and Norgold Russet.

Chemical Control

Protectant materials including maneb, mancozeb, chlorothalonil, triphenyltin hydroxide and fixed coppers must be applied to asymptomatic foliage before infection begins. Complete coverage and repeat applications of protectants as new foliage emerges is important. Metalaxyl with mancozeb, chlorothalonil or fixed copper may provide systemic and curative control of susceptible strains of the late blight fungus. Historically, the fungicide metalaxyl (Ridomil MZ58/Bravo 81W and Ridomil/Copper 70W) has been highly effective for late blight control in Wisconsin. During 1994, some potato fields were observed that were attacked by a metalaxyl sensitive genotype of the A1 mating type (20% of potato isolates) and many fields attacked by the aggressive US-8 genotype (80% of potato isolates). All potato isolates of the US-8 mating type were insensitive to metalaxyl fungicide while all of the US-1 isolates were still sensitive to metalaxyl. Many growers who relied on treatment with metalaxyl fungicide combinations experienced a lack of late blight control, often with serious consequences to yield and tuber quality.

Fungicide Resistance

Strains of the late blight fungus which are insensitive to metalaxyl fungicide were observed in Wisconsin in 1993 and 1994. For an assay of metalaxyl sensitivity, send samples of late blight-infected leaves and tubers to Walt Stevenson, UW-Madison Department of Plant Pathology. There is a charge to cover the cost of this service.

References

Hodgson, W. A., D. D. Pond and J. Munro. 1974. Diseases and pests of potatoes. Canada Department of Agriculture Publication 1492. 69pp.

O'Brien, M. J. and A. E. Rich. 1976. Potato diseases. USDA Agriculture Handbook No. 474. 79pp.

Rowe, R.C. ed. 1993. Potato Health Management. American Phytopathological Society, Inc. 178pp.

Leaf Roll

Common Name: Net Necrosis

Cause: Potato Leaf Roll Virus

Type: Virus

General Information

Biological Description

Potato Leafroll Virus (PLVR) is one of many viruses which attack potatoes. At the present time, there are several strains of the virus which may occur naturally. All strains are transmitted by aphids.

Economic Importance

Leaf roll is one of the most serious virus diseases of potato. It is a disease of great economic impact since virus infection can cause a 30-50% reduction in yield. The severity of symptoms produced in potatoes depends on which virus strain infects the plant. The virus affects both the foliage and the tubers.

Disease Cycle

Transmission of the virus occurs primarily by the green peach aphid (*Myzus persicae*) and through infected seed pieces. Once an aphid has fed on an infected plant, it remains capable of transmitting the virus to healthy plants for the remainder of its life. At the time of symptom expression, necrosis of phloem tissue begins.

Host Range

The host range of potato leaf roll virus is restricted to members of the potato family: potato, tomato, jimsonweed, groundcherry and a few other weeds.

Environmental Factors

The severity of the leaf roll symptom varies with the virus strain as well as with the temperature. Plants growing under very high temperatures (95 degrees F) will not show symptoms, but those grown under moderate temperatures at or below 77 degrees F show the characteristic leaf roll symptoms. Tubers produced from plants infected during the current growing season do not always show the net necrosis at harvest. Storage conditions may favor development of tuber symptoms. Maximum development of the net necrosis occurs when tubers are stored at temperatures near 50 degrees F for 2-3 months. Net necrosis may also increase during transit and marketing if tubers are maintained near 50 degrees F and are shipped early after harvest.

Symptoms

Initial symptoms become noticeable about one month after plants emerge if seed pieces are infected. Leaflets of the lower leaves roll up at the edges and become papery, brittle, and leathery to the touch. Affected leaves will "rattle" when shaken. The rolled leaves are lighter in color than normal. As the plant grows, the rolling appears on the upper leaves and eventually affects the whole plant. In some varieties, the lower leaf surfaces may take on a purple cast. Plants are often stunted. If late season infection occurs, plants may show no symptoms. Plants infected by aphids show their initial symptoms on the young leaves. Symptoms are similar to those expressed on plants resulting from infected tubers. As the disease progresses, symptoms begin to appear on the lower plant parts.

Net necrosis occurs on tubers. A network of brown strands appear throughout the tuber flesh, especially near the stem end. The appearance of the strands varies with the angle that the tuber is cut. In cross sections, they show up as dots or streaks; lengthwise cuts show the network of brown strands. Plants infected during the season produce tubers with net necrosis; plants produced from seed pieces with net necrosis produce infected, but sympomless tubers.

Scouting Procedure/ET

Please refer to the plant pest profile on the green peach aphid for scouting procedures and economic thresholds.

Integrated Control

Non-Chemical Control

Cultural Control: Good cultural practices and the use of resistant varieties aid in the control of potato leaf roll. Plant only seed potatoes which have been certified as disease free since the virus is transmitted in tubers with or without the net necrosis symptom. Grow potatoes in isolated fields - away from prevailing winds coming from other potato fields. Winds may blow aphids that may vector the virus. Control aphid populations. Rogue all plants showing symptoms of virus infection throughout the season. The virus is not easily transferred by sap, but aphids can transmit the virus from one infected plant to non-infected plants in a field.

Resistant Varieties: Several potato varieties are resistant to the potato leaf roll virus. These include Abnaki, Alamo, Cherokee, Chieftan, Houma, Katahdin, Kennebec, Merrimack, Pungo, Redskin, Reliance, Saco, Sebago, Wauseon, and Yukon Gold. Varieties that are susceptible and should be avoided include Green Mountain, Irish Cobbler, Norland and Russet Burbank. Penobscot and Sequoia are resistant to leaf roll, but are susceptible to net necrosis. Atlantic, Chippewa and sometimes Wauseon are susceptible to leaf roll but are resistant to net necrosis.

Chemical Control

There is no chemical control for the virus itself, however, insecticide applications to reduce aphid populations can effectively limit the spread of the potato leafroll virus. Please refer to the plant pest profile on the green peach aphid for chemical pesticide recommendations.

Fungicide Resistance

None.

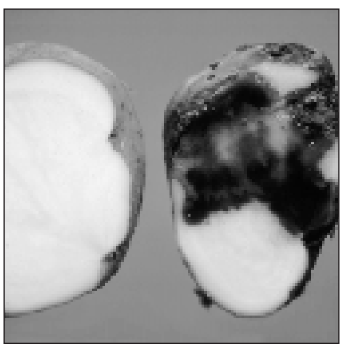
References

Compendium of Potato Diseases. 1981. American Phytopathological Society Press. St. Paul, MN. 125pp.

Leak

Cause: *Pythium ultimum* and *P. debaryanum*

Type: Fungus



General Information

Biological Description

Pythium belongs to the group of fungi known as water molds.
The mycelium is coenocytic (without cell walls) and delicate.

Economic Importance:

Leak is the name given to a watery rot of potato. It is most serious in moist soils and in years with heavy rainfall. The disease is a problem only when potatoes are harvested and transported during warm weather.

Disease Cycle

Pythium is a soilborne fungus and enters the tubers through wounds.

Host Range

Pythium has a wide host range. It affects many types of vegetables at different stages of growth and causes various types of diseases. Root rot and damping-off are the two major types of diseases caused by the pathogen. Among those vegetables attacked by Pythium are bean, cabbage, celery, cucumber, lettuce, melon, pea, pepper, potato, rhubarb, spinach, sweet potato, and tomato.

Environmental Factors

The fungus is present in the soil and usually invades tubers through wounds. Infection of tubers occurs in tubers that are damaged by sunburn or sunscald and in tubers which are allowed to remain in, or on, hot soils after being harvested. Hot, unusually wet weather favors the development of this disease. Entire tubers may rot in a few days at 77 degrees F, but decay develops slowly between 40-50 degrees F.

Symptoms

Infected tubers of white-skinned varieties often have light to dark-brown lesions on the surface. Internally, the affected tissues are creamy at first, but as the disease progresses, the tissues soon turn tan or slightly reddish, then brown, and finally inky black. The diseased areas are sharply set off from the healthy tissue and often only a shell of sound tissue remains. The flesh of infected tubers is granular, soft, and very watery. The most characteristic symptom of leak is the extremely watery condition of affected tissues. When pressure is applied to the infected tubers, a clear liquid is readily expelled. Leak infected tubers are often secondarily invaded by bacteria. These bacteria check the growth of the leak organism and produce foul-smelling, sticky, or slimy decays.

Scouting Procedure/ET: *None.*

Integrated Control

Non-Chemical Control

Cultural: Do not grow potatoes on heavy, poorly drained soils. Harvest tubers when they are fully mature especially in wet years. Take care to avoid bruising and injuring the skin. Keep potatoes as dry as possible going into storage and store them at cool temperatures. Do not let freshly harvested tubers sit in the sun without canvas tarps. Move harvested tubers to storage as quickly as possible.

Resistant Varieties: None.

Chemical Control: None.

Fungicide Resistance: None.

References:

Compendium of Potato Diseases. 1981. American Phytopathological Society Press. St. Paul, MN. 125 pp.

Lesion Nematode

Cause: *Pratylenchus penetrans*

Type: Nematode

General Information

Biological Description

Nematodes are microscopic, unsegmented roundworms. The lesion nematode is a damaging parasite of potatoes.

Economic Importance

Lesion nematodes damage both the roots and tubers of potatoes. Nematode infestations can reduce plant growth by almost 60% and can cause losses in tuber yields of 20-50%. The feeding of these nematodes may predispose potatoes to other diseases, or the nematodes may act with other pathogens in the development of potato disease complexes.

Disease Cycle

The lesion nematodes are endomigratory parasites and move freely into and out of roots. Eggs are laid in the soil or within the root. Nematodes undergo the first of their molts while still in the egg. Upon emerging from the egg, second instar larvae penetrate unsuberized areas of the root. All developmental stages can enter the root. Penetration is achieved by cutting the tissue with their stylet. Typically, the larvae feed and develop into adults within 40-45 days depending on temperatures and other environmental conditions. It takes between 4-8 weeks to complete one generation.

Host Range

The host range of the lesion nematode is very wide. In this case, a host is defined as a plant on which the nematode can reproduce. Over 500 species of plants including ornamentals, field and vegetable crops, and weeds are attacked by this nematode. Crops commonly infected include apple, beet, cabbage, carrot, corn, forages, grape, grasses, mint, onion, pea, potato, soybean, strawberry, and tomato.

Environmental Factors

Lesion nematodes are inhabitants of the soil and occur throughout Wisconsin. They are more common and cause more damage in sandy soils, but they may also be abundant in heavier soils with more clay. Optimum temperatures for reproduction are between 70-85 degrees F. Alternate freezing and thawing of the soil tends to kill the nematodes quicker than continuously low temperatures. Lesion nematodes require moderate soil moisture for migration from plant to plant. Some species however, are relatively resistant to drought.

Symptoms

Above-ground symptoms of severely affected potato plants are manifested in poor growth. In the field, affected plants often appear in patches with stunted growth and chlorosis. Sometimes, affected plants may show no obvious above-ground symptoms. Underground symptoms are more obvious. Roots may be girdled at the infection site so that the outer tissue layers will readily slip off from the central cylinder. The nematodes cause root necrosis, often visible externally as darkened lesions. Small feeder roots are often completely destroyed, resulting in a reduced root system. Internally, nematodes tunnel through root tissue as they feed, damaging root cells. This damage causes plants to grown poorly with reduced yields. Where nematodes feed on tubers, pimples appear that later change to black depressions. When infection is severe and pimples and depressions are numerous, tubers are marred and become unmarketable. The nematode may act with other diseases such as fusarium or verticillium wilts in the development of potato disease complexes.

Scouting Procedure/ET

Monitor potato fields weekly and note any symptoms of stunting or chlorosis. Soil samples can determine the presence and relative abundance of nematodes in fields expressing symptoms.

Integrated Control

Non-Chemical Control

Cultural Control: Lesion nematodes can be controlled by sound cultural practices, tolerant varieties, and nematicides. Always plant nematode-free seed pieces. Plant as early as possible. Practice crop rotation. Non-host crops grown for 1-2 years will generally reduce the nematode population so that potatoes may be grown for at least one year. Good weed control is necessary as the nematodes can reproduce on many weeds. Plowing, disking, harrowing, and cultivation after harvest helps to reduce nematode populations by exposing them to sun, wind, and mechanical injury as well as depriving them of a living host.

Resistant Varieties: None.

Chemical Control

Soil fumigation with metam sodium can successfully reduce nematode populations in infested fields, however, the cost may be prohibitive. In addition, soil fumigation is of limited effectiveness on heavier soils. A minimum of three weeks is necessary between fumigation and planting to prevent phytotoxicity.

Fungicide Resistance

None.

References

Compendium of Potato Diseases. 1981. American Phytopathological Society Press. St. Paul, MN. 125 pp.

Phoma Tuber Rot

Cause: Phoma spp.

Type: Fungus

General Information

Biological Description

Phoma belongs to the group of fungi known as the Imperfects and may be identified by its tiny flask-shaped pycnidium or fruiting structure. Spores produced by the fungus are single-celled and hyaline.

Economic Importance

Phoma tuber rot is a disease of potato tubers in storage. Infected potatoes may be rejected for seed or table stock.

Disease Cycle

Spores are spread by rain and soil movement. Infection occurs primarily through wounds or through eyes and lenticels. Infection may occur in the lesions produced by other pathogens such as powdery scab. Uninjured tubers are not usually infected. Seed pieces that do not heal properly may also be attacked. The disease usually causes infection on sections of the tuber but rarely destroys the entire tuber.

Host Range

All varieties of potato are susceptible to this disease.

Environmental Factors

The continuous planting of potatoes from year to year will increase the amount of inoculum in the soil. Cool, dry storage conditions which do not favor the healing of wounds favor tuber infection.

Symptoms

The surfaces of infected tubers have brown to gray lesions resembling depressions caused by the thumb. The lesion darkens with age and the skin becomes papery. Cracks or tears may appear in the skin over the lesion, which gives the appearance of a ragged buttonhole. The tissue underneath is black, shrunken, and decayed. Black fruiting bodies called pycnidia may develop on the tuber in storage. Phoma rot usually affects only part of the tuber.

Scouting Procedure/ET: None.

Integrated Control

Non-Chemical Control

Cultural Control: Plant disease-free seed pieces and plant on uninfested soils. To prevent the build-up of inoculum in the soil, practice long crop rotations. Avoid wounding tubers during harvesting and grading. Store tubers at 65 degrees F or higher for 10 days to promote rapid wound healing.

Resistant Varieties: The variety Caribe is resistant to Phoma tuber rot; Fundy, Katahdin, Kennebec, and Irish Cobbler are moderately resistant to the rot, but Sebago and Green Mountain are susceptible.

Chemical Control: None.

Fungicide Resistance: None.

References

Compendium of Potato Diseases. 1981. American Phytopathological Society Press. St. Paul, MN. 125 pp.

Potato Latent Virus

Common Name: Potato Mild Mosaic Virus

Cause: Potato Virus X

Type: Virus

General Information

Biological Description

Potato virus X is a filamentous virus with a single strand of RNA. Isolates may be grouped into strains through several methods. Within the potato leaf cells, large inclusions may be seen on plants infected with potato virus X.

Economic Importance

Potato virus X is almost universally present in the commercial potato stocks of America, where it is known as the “healthy potato virus”. Most currently grown varieties show no symptoms or only a very mild mottle with little plant stunting or deformation of foliage. However, yield loss may reach 15% or more. The virus does not affect the eating or selling qualities of the potatoes, but can reduce the number and size of the tubers produced. Virus-infected tubers should not be used for propagation of certified seed stock.

Disease Cycle

Potato virus X is transmitted by equipment, wind, plant to plant contact, and insect feeding by chewing insects such as grasshoppers.

Host Range

Potato virus X infects several members of the potato family. In addition to potato, tomato, petunia, tobacco, jimson weed, night-shade, henbane, and tree tomato are susceptible.

Environmental Factors

The symptoms of potato virus X in susceptible varieties are severe in cool temperatures of 60-68 degrees F. Weather conditions above 85 degrees F may completely mask the symptoms.

Symptoms

Many potato varieties are symptomless carriers of this virus, that is the virus is latent in them. However, some varieties show an acute reaction such as tip kill, to this virus. The virus moves up through the plant killing the tip and the plant dies from the top downward. In these varieties, tubers may not develop. Still other varieties have plants with leaves mottled in shades of light and dark green. This mottling varies from inconspicuous to very noticeable with a rugose texture to the leaves as well. The leaves of these infected plants may have tiny brown, dead spots on them. Infected plants may or may not be stunted.

Scouting Procedure/ET

Monitor fields weekly for symptomatic plants. Rogue out any symptomatic plants as soon as they are detected to prevent transmission of the virus to healthy plants.

Integrated Control

Non-Chemical Control

Cultural Control: Use a high grade of certified seed as potato virus X is transmitted in seed pieces and from one piece to another on knives used to cut the pieces. Sterilize knives between cuts if possible. Rogue out all plants with obvious mosaic as soon as detected. The virus can spread to healthy plants by the rubbing of infected leaves on healthy ones in the wind and by healthy tuber sprouts touching infected plants. Roguing can reduce the possibility of this type of spread.

Resistant Varieties: Atlantic and Michibonne are immune to potato virus X. Among the varieties that are field-resistant to potato virus X are Butte, Chippewa, Hunter, Katahdin, Reliance, Saco, Sebago, Tawa and Wauseon. The variety Superior is only slightly susceptible to the virus. Arran Crest, Epicure, Irish Cobbler, and King Edward show the tip kill symptom. Very susceptible varieties are Bliss Triumph, Green Mountain, Norchip, Norland, Russett Burbank, and Warba.

Chemical Control: None.

Fungicide Resistance: None.

References

Compendium of Potato Diseases. 1981. American Phytopathological Society Press. St. Paul, MN. 125 pp.

Rhizoctonia Canker

Common Names: Black Scurf, Stem Canker

Cause: *Rhizoctonia solani*

Type: Fungus

General Information

Biological Description

Mycelium of rhizoctonia is tan to brown in color. Characteristic right-angle branching with a constriction and septum near the junction easily identifies the fungus.

Economic Importance

Rhizoctonia canker is a very common and serious disease of potato. An expression often applied to this disease is “the dirt that won’t wash off” referring to the dark resting structures (sclerotia) on the mature tubers. The presence of sclerotia on the tuber surface may adversely affect the tuber grade. Yield losses are mainly due to uneven stands that produce small, irregular-shaped potatoes.

Disease Cycle

Rhizoctonia overwinters in the soil as sclerotia. These resting spores germinate in the spring under favorable conditions and attack developing plants through wounds. Disease development is rapid in cool, wet weather.

Host Range

Rhizoctonia has a wide host range. In addition to potatoes, the fungus also affects beet, cabbage, carrot, celery, cucumber, eggplant, lettuce, melon, onion, pepper, rhubarb, soybean, snap bean, spinach, squash, and tomato.

Environmental Factors

The fungus lives indefinitely in the soil on plant debris. The conditions that favor disease are high moisture, cool soil temperatures, high soil fertility, and soil with a neutral or acidic pH.

Symptoms

The fungus causes dark-brown lesions on roots, stolons, and sprouts. Infection may be so severe that it may kill the infected plant part or the tips of sprouts before or after they emerge. If the infection is mild, plants only show a lack of vigor. The leaves of infected plants become thick and sparse, roll upward, and turn pinkish to purple in color. The stalks may also thicken and bear green or reddish aerial tubers. The underground tubers develop in a tight cluster with small, numerous, and irregularly shaped tubers. Affected tubers may be cracked or pitted. The most common symptom of Rhizoctonia canker is the presence of numerous, hard, dark-brown resting bodies called sclerotia on the surface of mature tubers. These sclerotia may vary from the size of the head of a pin to 1/4 inch in diameter. Sclerotia are often mistaken for adhering soil until it is found that they do not wash off.

Scouting Procedure/ET

Monitor fields weekly throughout the growing season for symptoms of the disease on aerial portions of the plant. During harvest and grading, inspect tubers for discoloration.

Integrated Control

Non-Chemical Control

Cultural Control: Rhizoctonia canker is very difficult to control. Always plant disease-free, certified seed. Avoid planting in cold, wet soil. Shallowly planted seed will emerge more quickly and may suffer less infection when conditions are favorable for the disease. Rotate potatoes with cereals, grasses, or some other type of green cover crop that is plowed under before potatoes are planted. Crop rotation is also useful in preventing other potato diseases. Harvest tubers as soon as they are mature to reduce the number of sclerotia that develop on the tubers.

Resistant Varieties: None.

Chemical Control: None.

Fungicide Resistance: None.

References

Compendium of Potato Diseases. 1981. American Phytopathological Society Press. St. Paul, MN. 125 pp.

Rugose Mosaic Virus

Cause: Potato Virus Y

Type: Virus

General Information

Biological Description

Potato virus Y appears to be the primary cause of rugose mosaic however, the presence of absence of potato virus X also influences the symptom expression. There is a difference of opinion as to whether rugose mosaic is caused by potato virus Y alone or by potato viruses X and Y. There are many groups of the virus which may cause varying symptoms.

Economic Importance

Rugose mosaic is a serious disease of potato. It is especially important because it causes degeneration or “running out” of tubers. Potato virus Y is capable of causing complete crop failure. It is most serious when potato virus X is present concurrently.

Disease Cycle

The virus is transmitted from infected plants to healthy ones on the stylet of aphids, primarily the green peach aphid (*Myzus persicae*).

Host Range

Several members of the potato family are susceptible to potato virus Y. Potato, tobacco, tomato, nightshades, petunia, henbane, and tree tomato are all affected.

Environmental Factors

Leaf mottling caused by potato virus Y infection may not show at high temperatures. However, the virus spreads through the plant faster at high temperatures than at low temperatures.

Symptoms

The severe symptoms of rugose mosaic make it easy to identify from other mosaics on potato. In the first year of infection, black streaks develop in the veins, leaf stalks, and stems which cause the leaves to shrivel. The leaves are left hanging on the plant by the withered petiole. Some leaves become so brittle they drop from the plant. One or more shoots may be infected in one hill, but by the end of the season, most, if not all shoots from one hill will be affected. Infected plants die prematurely.

Plants emerging from tubers infected with potato virus Y are dwarfed. The leaves on these plants are severely mottled, wrinkled, distorted, and reduced in size. The leaf stalks are brittle. Veins on the lower leaf surface of infected leaves show brown areas resembling black lines drawn with a pencil. Tubers produced on these plants are smaller than those produced on healthy ones. Rugose mosaic is distinct from other mosaics on potato because the mottled areas are numerous, smaller, and more conspicuous.

Scouting Procedure/ET

Please refer to the plant pest profile on the green peach aphid for more information on scouting procedure and economic thresholds.

Integrated Control

Non-Chemical Control

Cultural Control: Plant certified disease-free seed potatoes. Rogue any plants that show mottling. Start rogueing when plants are 5-6 inches high and check every 7-10 days for new infections. Potato virus Y can be transmitted by the rubbing of healthy plants against infected ones or by equipment or people touching infected plants followed by healthy ones. Plant potato fields in locations where the prevailing wind will not blow aphids in from other potato fields.

Resistant Varieties: Presently, there are no potato varieties commercially available that are immune to potato virus Y, but many varieties such as Chippewa, Katahdin, Kennebec, Monona, Russet Burbank, and Sebago have good tolerance to the disease. Russet Nordotch is a symptomless carrier under some conditions and does not readily express symptoms of this disease.

Chemical Control

Control aphid populations with insecticides when threshold levels are reached. Please refer to the plant pest profile on the green peach aphid for chemical pesticide recommendations.

Fungicide Resistance: None.

References

Compendium of Potato Diseases. 1981. American Phytopathological Society Press. St. Paul, MN. 125 pp.

Secondary Tubers

Cause: Unfavorable Storage and Growing Conditions

Type: Environmental

General Information

Biological Description

Secondary tubers develop from the eyes or sprouts of seed pieces.

Economic Importance

This disorder is important because foliage may never develop from such seed pieces resulting in a poor field stand. In general this disorder is a minor problem in potato production areas.

Disease Cycle

This disorder is not pathogenic in nature.

Host Range

All varieties of potato are susceptible.

Environmental Factors

Secondary tubers develop when stored tubers or seed pieces have completed the rest period. The disorder is due to a low level of carbohydrates in the tubers. When conditions are not favorable for normal vegetative growth, sprout tubers or secondary tubers develop. This condition may be induced by high storage temperatures, removal of sprouts, or planting in cold, dry soil.

Symptoms

Several small tubers may form out of an eye or on sprouts of seed pieces and/or on tubers in storage. These small tubers often resemble beads on a string or they may form in clusters at the end of short sprouts. A poor field stand is the first sign of secondary tuber formation. Potato growth stops and leafy shoots seldom develop.

Scouting Procedure/ET

None.

Integrated Control

Non-Chemical Control

Cultural Control: To avoid formation of sprout tubers, place seed potatoes in cool storage. Avoid high storage temperatures and unusually long exposure to light. Do not plant seed pieces in cold, dry soil.

Resistant Varieties: None.

Chemical Control

Do not use thiabendaxole fungicide on seed pieces of cultivars other than Russet Burbank. This fungicide can induce secondary tuber formation on some cultivars such as Monona, Ontario and LaChipper.

Fungicide Resistance: None.

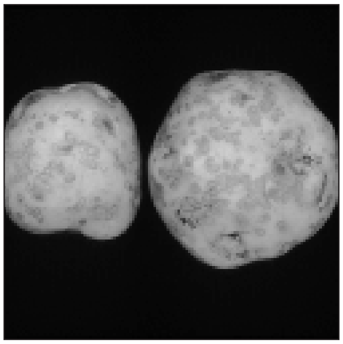
References

Compendium of Potato Diseases. 1981. American Phytopathological Society Press. St. Paul, MN. 125 pp.

Silver Scurf

Cause: *Helminthosporium solani*

Type: Fungus



General Information

Biological Description

Helminthosporium is characterized by its hyaline or translucent mycelium that darkens with age. Conidia are produced in whorls on conidiophores. Individual conidia are large, thick-walled, and septate.

Economic Importance

Silver scurf is a common and widespread potato disease. It has previously been considered of little economic importance. However, the increasing demand for "clean" potatoes has recently made it a major problem. This is particularly true where potatoes are washed before being offered for sale in plastic bags. When potatoes are grown on muck soil, the blemishes produced by this fungus may cause reduction in grade or prevent seed certification. Periderm infection may result in increased fresh weight loss through alteration of the periderm.

Disease Cycle

The fungus overwinters in infected tubers in storage and those left in the soil after harvest. Tubers become susceptible at the time of maturity while they are still in the soil and remain susceptible throughout storage. Healthy tubers are infected through wounds or lenticels.

Host Range

All potato varieties are susceptible to some degree.

Environmental Factors

High soil moisture and humidity favor disease development.

Symptoms

The symptoms of silver scurf seem to be confined to the tubers. Light to dark brown round or irregular spots develop on the tuber surface. On wet tubers, the spots are silvery and glassy and easily observed. After prolonged storage under warm moist conditions, spores may form in the diseased spots which makes them look sooty or smudgy. The affected areas become black and may develop small black lumps. The affected skin sloughs off and tubers shrivel and shrink. The color of red-skinned potatoes may be completely destroyed by the disease.

Scouting Procedure/ET

None.

Integrated Control

Non-Chemical Control

Cultural Control: Plant disease-free seed pieces and practice crop rotation to reduce the incidence and severity of the disease. Harvest tubers as soon as they are mature, cull out noticeably infected tubers at digging and grading, and store healthy tubers in a cool, dry place.

Resistant Varieties: None.

Chemical Control: None.

Fungicide Resistance

Strains of this pathogen are resistant to thiabendazole fungicide while other strains are still susceptible to normal use patterns of this material.

References

Compendium of Potato Diseases. 1981. American Phytopathological Society Press. St. Paul, MN. 125 pp.

Simple Mosaic Virus

Common Name: Internal Mosaic

Cause: Potato Viruses X, M, and S

Type: Virus

General Information

Biological Description

The viruses X, M, and S are all straight filamentous-type viruses. Several tests are available to distinguish between the viruses.

Economic Importance

Simple mosaic is the most common of all potato virus diseases. It is found in almost every crop of susceptible potato varieties grown for table stock. The disease complex does not affect the eating or marketing quality of the potatoes. However, tubers with the virus infection can not be used as seed potatoes. Tubers produced from virus infected plants are smaller than tubers produced on healthy plants and the reduction in yield is comparable to the reduction in size and vigor of the infected plants.

Disease Cycle
The viruses associated with simple mosaic are transmitted by the following aphids: green peach aphid (*Myzus persicae*), potato aphid (*Macrosiphum euphorbiae*), and the buckthorn aphid (*Aphis nasturtii*).

Host Range
Potato virus X infects potatoes, tomato, petunia, tobacco, jimson weed, nightshades, henbane, and tree tomato. Potato virus S has a narrow host range which includes potato and tobacco. Both X and S may infect plants in the goosefoot family (Chenopodiaceae) and the legume family.

Environmental Factors
In hot weather, the symptoms are reduced in severity and often masked or very mild. Mottling symptom is most obvious in cool weather.

Symptoms
Infected plants are mottled between the veins. Symptoms vary from conspicuous to barely noticeable. The plants may have slightly rugose leaves with an upward roll. Plants may or may not be stunted. Symptom expression may vary with the potato variety affected.

Scouting Procedure/ET
Please refer to the plant pest profile on the green peach aphid and the potato aphid for more information on scouting procedures and economic thresholds.

Integrated Control
Non-Chemical Control
Cultural Control: Plant only certified disease-free seed pieces. Rogue out plants with obvious mosaic as soon as they are found although this practice is not always effective. All three viruses can be transmitted by sap from an infected plant rubbing against adjacent healthy plants. Always practice good sanitation to prevent spreading the disease by human contact. Control aphid populations.

Resistant Varieties: The varieties Katahdin, Chippewa, and Sebago are resistant to potato virus X while Katahdin, Kennebec, and Saco are resistant to potato virus S. Norland is susceptible to simple mosaic.

Chemical Control
Please refer to the plant pest profiles on the green peach aphid and the potato aphid for information on chemical control recommendations.

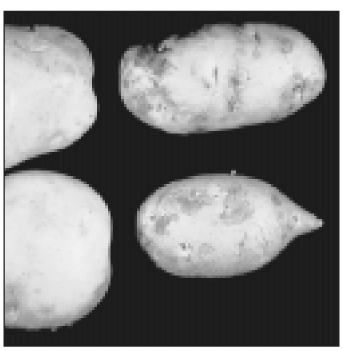
Fungicide Resistance: None.

References
Compendium of Potato Diseases. 1981. American Phytopathological Society Press. St. Paul, MN. 125 pp.

Spindle Tuber

Cause: Spindle Tuber Viroid

Type: Viroid



General Information
Biological Description
The organism responsible for spindle tuber is a viroid which contains a small amount of RNA.

Economic Importance
Spindle tuber is not as widespread as some virus diseases of potato such as the mosaics or potato leaf roll. It is serious however, because it may affect 15-25% of the plants where it occurs. Its presence can cause reduction in yield and when attacks are severe, it can cause a reduction in grade.

Disease Cycle
The spindle tuber viroid is transmitted mechanically by cultural activities associated with growing potatoes.

Host Range
Potato spindle tuber viroid infects and causes symptoms in potato, tomato, and tobacco. The virus infects ground cherry without causing symptoms.

Environmental Factors
The foliage symptoms are most prominent at high temperatures and may be masked at low temperatures.

Symptoms
The symptoms on the foliage are difficult to detect, but the elongated tuber symptoms is obvious. Affected plants are erect, slightly stunted, and usually darker green than normal. Leaflets may be smaller than usual and the leaves are set at a sharp angle to the stem and make the plant look stiff. The leaves and stem may appear twisted.

The disease gets its name from the shape of tubers produced by diseased plants. The tubers from infected plants are elongated and have tapered ends. The eyes are more numerous and conspicuous in virus-infected potatoes. A distinct "eyebrowing" of the tuber flesh occurs over each eye. Red skinned potato varieties sometimes fade when infected and the skin of russetted varieties become smooth.

Scouting Procedure/ET

Monitor fields weekly early in the season to identify and remove any plants showing symptoms of the virus.

Integrated Control

Non-Chemical Control

Cultural Control: Spindle tuber is a disease that is difficult to control. Always plant certified, disease-free seed. The viroid is transmissible through any means that transmits sap from one plant to another. It is important to sterilize knives and other equipment used in seedpiece preparation. Rogue diseased plants early in the season. Complete cultivation and hilling of the plants while they are small to avoid plant to plant dissemination by cultivation equipment. The pathogen is also transmitted by several types of insects such as grasshoppers, flea beetles, plant bugs, and the larvae of the Colorado potato beetle. Therefore, control of these insect vectors is important in the control of the disease.

Resistant Varieties: Most commonly grown potato cultivars are susceptible to potato spindle tuber disease.

Chemical Control: None.

Fungicide Resistance: None.

References

Compendium of Potato Disease. 1981. American Phytopathological Society Press. St. Paul, MN. 125 pp.

Tuber Greening

Common Name: Light Burn, Sunburn

Cause: Exposure of Tubers to Light

Type: Environmental

General Information

Biological Description

Potatoes exposed to light either before or after harvest, gradually turn green at the surface because of the development of chlorophyll.

Economic Importance

Greened potatoes are unmarketable. The affected potatoes have a bitter taste and may be dangerous to eat since a toxic alkaloid develops in the green areas.

Disease Cycle: None.

Host Range

All potato varieties are susceptible to tuber greening, however some varieties which characteristically set their tubers near the soil surface are more likely to be affected.

Environmental Factors

Greening can occur while potatoes are in the field, in storage, transit, or in the retail store. Greening occurs more rapidly at warm temperatures of 70 degrees F or greater. Light intensities as low as five foot-candles may induce greening. As the light intensities increase, so does the greening. Little solanine is produced when tubers are exposed only to artificial light.

Symptoms

After exposure to sunlight or artificial light for two or more days, a green pigment develops in the skin and slightly below the skin in the flesh of the tuber. The flesh of the tuber may be yellow or greenish-yellow. The longer the exposure to light, the greener the pigment will become. Chlorophyll, which is the compound responsible for the green pigment; and solanine, the alkaloid produced, develop when the tubers are exposed to light. Solanine is a bitter compound which may be toxic if taken in sufficient doses. Immature tubers tend to green more readily than mature tubers.

Scouting Procedure/ET: None.

Integrated Control

Non-Chemical Control

Cultural Control: In the field, most greening results from shallow planting or improper hilling. Plant potatoes deep enough and hill them well so that they will not grown near the soil surface. Store potatoes in the dark, even under home conditions. Protect potatoes from exposure to light during marketing with light-proof containers. Rotate potatoes on display in the market to avoid greening.

Resistant Varieties: Most potato varieties are susceptible to greening, notably Kennebec, as well as other varieties that produce their tubers near the soil surface. Potato breeders are working to develop new varieties that will be less prone to tuber greening.

Chemical Control: None.

Fungicide Resistance: None.

References

Compendium of Potato Diseases. 1981. American Phytopathological Society Press. St. Paul, MN. 125 pp.

Field Survey of Potato Diseases

General Instructions

1. Sample Site Selection

Three sample sites should be selected for each 40 A field area. Location of each sample site will generally be a compromise between convenience of access and favorability to disease development. Sites in close proximity to windbreaks, isolated trees, or other obstructions are often favorable to disease development since air circulation is often reduced in these areas. In addition, aerial application of pesticides may be impeded by these same obstructions.

2. Sample Site Layout

For each sample site, select four rows, approximately ten feet in length, separated by single, unscouted rows. Each scouted row should represent ten individual potato plants. (See diagram below.)

____________________________40 feet______________________________

Row 'a'
XXXXXXXXXX

Row 'b'
XXXXXXXXXX

Row 'c'
XXXXXXXXXX

Row 'd'
XXXXXXXXXX

Permanently flag each sample row such that the same plants in the same rows are rated at each sample period.

3. Potato Disease Rating

a) Horsfall-Barratt Rating System

This system is widely used to estimate disease incidence of diseases affecting plant foliage. It is based on the premise that a person's ability to distinguish small differences in percent disease is best near zero or 100% and poorest near 50%. When using this system, scouts should first decide whether disease incidence is greater than or less than 50% of its foliage affected and then select the appropriate rating score that best represents the amount of disease present. The four rating scores recorded at each sample site will be converted to "percent disease" by the IPM staff using a mathematical formula.

Disease Rating Score (Record on Field Report)	Percent Interval of Foliage Infected
0	No disease observed
1	0 to 3
2	3 to 6
3	6 to 12
4	12 to 25
5	25 to 50
6	50 to 75
7	75 to 88
8	88 to 94
9	94 to 97
10	97 to 100
11	100% All foliage infected.

Rating scores are based on the percent foliage infected. Include foliage lost (defoliated) due to disease in this rating score. You must decide whether leaf lesions and defoliation are due to infection by the early blight fungus or late blight fungus. Consult your color photographs in 'Potato Diseases' for reference. Collect samples for confirmation if you have difficulty deciding which disease is present.

b) Percentage of Plants Infected

This system is used to record the incidence of diseases affecting individual plants or groups of plants. The system is used wherever information on the degree of severity is not essential.

Specific Instructions

1. Early Blight

Key:

Brown to black lesions with concentric rings on leaves. Lesions are usually produced on lower senescent leaves.

Significant yellowing may accompany lesions.

Survey Method:

Horsfall-Barratt Disease Rating System—weekly.

2. Late Blight

Key:

Spreading dark-brown to black lesions on leaves and stems. White fungal growth may appear on underside of leaf lesions, especially under prolonged humid periods. A characteristic odor accompanies diseased plants. In dry weather, infected leaves turn brown and dry.

Survey Method:

Horsfall-Barratt Disease Rating System—weekly.
Collect Specimens for Laboratory Confirmation

3. Early Dying

Key:

Premature plant senescence with yellowing of lower leaves, followed by wilting of foliage. Discoloration of cortical and/or tissues in lower stem may be observed.

Survey Method:

Horsfall-Barratt Disease Rating System—weekly, once the problem begins to appear.

4. Rhizoctonia Canker

Key:

Uneven stand of weakened plants that lack vigor. Underground young shoots, stolens, and stems are wholly or partly girdled by long, reddish-brown lesions.

Survey Method:

Percentage of Plants Infected (eg-2/10)
A single survey once when plants are 10-12 inches tall should be sufficient.

5. Virus

Key:

Light mottle and distortion of leaves. In severe cases, plants will be stunted.

Survey Method:

Percentage of Plants Infected (eg-2/10)
A single survey once near the time of row close should be sufficient.

6. White Mold

Key:

Light colored, soft rot of potato stems. The mycelium of the fungus grows over the stem surface. Dead stems turn brown and may become filled with black sclerotia.

Survey Method:

Percentage of Plants Infected (eg-2/10)
A single survey 2-3 weeks after row close may be sufficient. However, if white mold is detected at any time during the growing season, weekly surveys should be conducted from the time of disease appearance until vine kill.

7. Blackleg

Key:

Typical symptoms of blackleg include dark, inky-black and sometimes shiny lesions on stems and shoots. Symptoms should be recorded as POSTEMERGENCE BLACKLEG (typical symptoms on emerged shoots) (POB), PREEMERGENCE BLACKLEG (decayed seedpieces with typical blackleg infected nonemerged shoots) (PBR), and SEEDPIECE DECAY (seedpieces decayed before sprouting and emergence occurred) (SD).

Survey Method:

Percentage of Plants Infected (eg-2/10 POB, 1/10 PBR, 0/10 SD)
A single survey once when the plants are 6-10 inches will be sufficient. If additional postemergence blackleg (POB) is noted, a second survey may be necessary.

Contents   Snap Bean (SN)

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UW Extension

Diagnostic Guide

Snap Bean Growth Stages and Problems

1 - Pre-emergence

General Appearance	Specific Symptoms	Cause (s)
Skips in rows where plants fail to emerge	No seed planted	Planter failure Empty seed box
	Seed normal size, not swelled	Soil too dry
	Seed swelled, but not sprouted or with small sprout only	Seed not viable Soil too cold Soil too wet Fertilizer in contact with seed
	Rotted seed or seedling	Seed not viable Seed rot or seedling blight caused by various seed or soil-borne fungi
	Hypocotyl broken	Crust Seed planted too deep Compacted soil
	Hypocotyl thickened with normal root system	Crust
	Hypocotyl thickened with limited, stubby roots	Herbicide injury Insecticide injury
Seed eaten, dug up or sprout cut off	Seed, hypocotyl, or cotyledons hollowed out, tunnel in hypocotyl, snakehead symptoms	Seed corn maggots Wireworms
	Unemerged seedlings	Crows, pheasants, blackbirds, mice, groundhogs, ground squirrels, gophers

2 - Seedling to 1st flower bud

General Appearance	Specific Symptoms	Cause (s)
Uneven growth of plants	Variable plant height	Variations in planting depth, soil moisture etc. Poor growing conditions (cold, wet, dry, etc.) Seed bed not uniform (cloddy)
	Plants stunted, wilted, or dead in isolated areas of field	Root rot complex caused by various soil borne fungi Lightening Garden symphylans Wireworms Nematodes *(Root knot, root lesions, soybean cyst)*

2 - Seedling to 1st flower bud

General Appearance	Specific Symptoms	Cause (s)
	Only upper part of plant killed; regrowth typically appears at lower nodes	Frost Herbicide injury
General wilting	Leaves wilt from a loss of foliar turgor pressure	Drought Herbicide injury Root rot complex Aphids
Plants discolored	Pale green to yellow color between veins; first apparent on older leaves later becomes deep yellow, except at base of leaves	Magnesium deficiency (rare except of light textured soils)
	Light green to white mottling between veins of younger leaves	Manganese deficiency
	Irregular yellow mottling around edges of leaves; first apparent on older leaves; develops into a continuous irregular border, if severe, only center and base of leaves remains green	Potassium deficiency
	Pale green to yellow leaves	Nitrogen deficiency apparent on older leaves Nematodes Root rot complex Potato leafhoppers
	Yellowing and narrow to broad cream to light brown bands between leaf veins and along leaf margins	Air pollution injury
	Upper leaves yellow or redden; flowers may fail to develop; dieback of growing tip	Boron deficiency
	Early in season leaves turn yellow between veins; plants stunted	Zinc deficiency
	Uniform browning of leaves, possible leaf drop	Bentazon (Basagran) herbicide injury
Plants stunted	Unifoliated leaves slow to expand on seedlings; leaf surfaces crinkled and leaf margins cupped	EPTC (Eptam) herbicide injury
	Plants stunted and wilted	Garden symphylans Nematodes Root rot complex
	Plants with thickened hypocotyl and restricted root growth	Dinitroanine herbicide injury— trifluralin (Treflan), profluralin (Tolban)
	Young leaves cupped up with shortened veins and twisted stems	Dicamba (Banvel) herbicide injury
	Leaves puckered along veins	Virus infection

2 - Seedling to 1st flower bud

General Appearance	Specific Symptoms	Cause (s)
Leaves crinkled and deformed	Younger leaves thickened, paddle-shaped with parallel veins; larger plants show pronounced bending of stems that often crack; plants may lodge	2,4-D dicamba (banvel) herbicide injury
	Downward cupped leaf margins; some plant stunt	Manganese toxicity (low soil pH)
Lesions on leaves	Dead spots on young leaves	Dinose (Premerge) herbicide injury
	Irregular brown or bronze spots between veins on uppermost leaves	Sunscald
	Small reddish-brown pustules filled with reddish brown spores. Circular pustules often surrounded by a yellow halo	Rust
	Small water soaked of light green spots becoming reddish brown and dry. Little or no leaf yellowing. Pod infection may lead to distorted or malformed pods	Bacterial brown spot
	Small water soaked spots on leaves. Later a halo-like cone of greenish-yellowish tissue develops outside of water soaked area	Bacterial halo blight
	Small water soaked leaf spots becoming large brown lesions covering large areas of the leaf surface	Bacterial common blight
Leaf tissue removed	Small holes (1/4 to 1/2") near centers of first trifoliate leaflets	Seed corn maggot
	Leaves torn and ragged; large areas of tissue missing; stems may be cut off, broken, or have sunken dark bruises; regrowth typically appears at lower nodes	Hail

3 - 1st flower bud to harvest

Leaves discolored	Leaf tips yellow, general leaf curl and plant stunt	Potato leafhoppers
	Leaves yellow and wilt	Root rot complex
	Leaves yellow, turn brown and fall off, white cottony fungal growth and black fungal sclerotia present on stems and pods	White mold (*Sclerotinia*)
Leaf tissue removed	Ragged shedding of leaf tissue	Hail injury
	Tissue removed along leaf veins	European corn borer
	Irregular holes in leaves, usually extending from the leaf margins inward. Greatest damage near field margins	Grasshoppers

3 - 1st flower bud to harvest

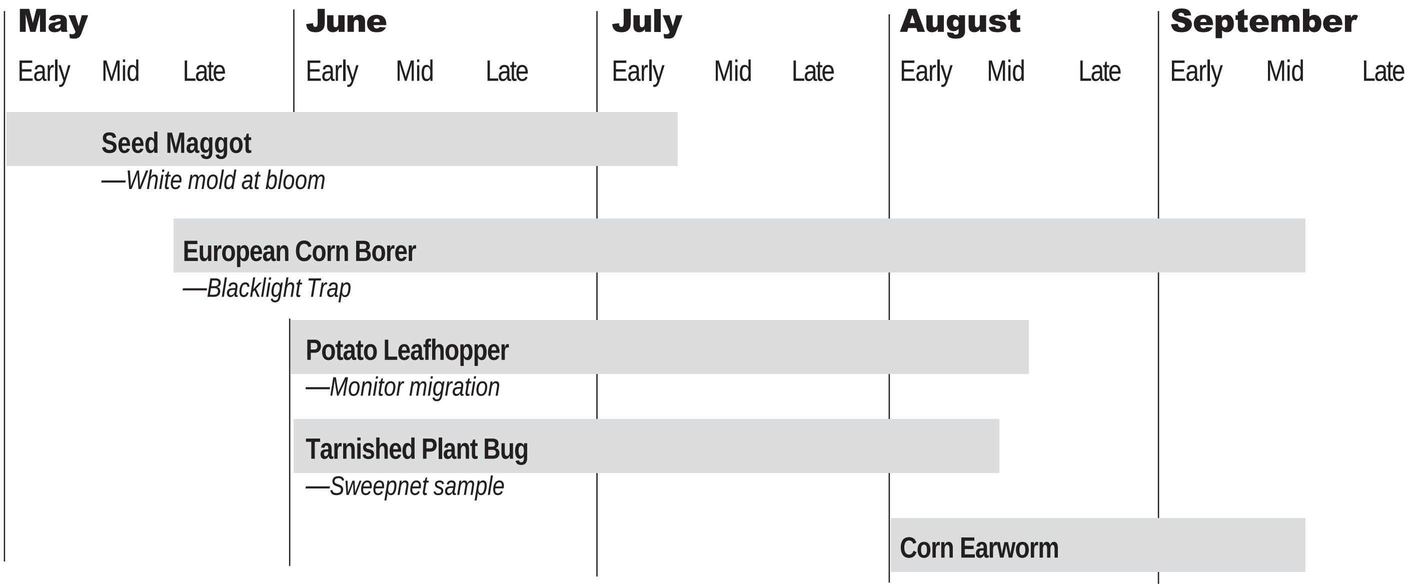
General Appearance	Specific Symptoms	Cause (s)
Discoloration of stems	Pale colored water-soaked lesions soon covered with white cottony fungal growth. Black sclerotia appear in later stages	White mold (*Sclerotinia*)
	Water soaked decay of stems and pods covered with grayish-green cottony fungal growth	Gray mold (*Botrytis*)
Holes in stem	External stem holes 1/8 inch diameter or less, internal tunneling, plant wilt	European corn borer
Plants die prematurely	Leaves yellow and wilt; brown girdling lesion on lower stem and primary root	Root rot complex
	All plant material in a circular area suddenly killed; lower parts of stem may be blackened and pith has a "cooked" appearance	Lightning injury
Flower and pin bean drop	Loss of flowers and "pin" size beans	Unfavorable temperature and moisture conditions, drought stress Spittle bug Tarnished plant bug 2,4-D, dicamba (Banvel) herbicide injury
Injury to the pods	Pods with smaller water soaked spots that become sunken and red-brown, pods distorted or malformed *(note leaf lesions)*	Bacterial brown spot
	Pods with water-soaked spots with bacterial exudate near center of pod lesion *(note leaf lesions)*	Bacterial halo blight *(exudate light cream or silver)* Bacterial common blight *(exudate yellow)*
	Pods remain small, become puckered, and are distorted	Bean yellow mosaic virus
	Irregular ragged holes chewed in pods, usually extending to seeds	Grasshoppers
	Pods curled and distorted accompanied by leaf distortion and cupping	2,4-D, dicamba (Banvel) herbicide injury
	Small holes often with internal feeding	European corn borer
	White cottony fungal growth on surface of pods accompanying watery decay	White mold (*Sclerotinia*)
	Gray-green cottony fungal growth on surface of pods accompanying watery decay	Gray mold (*Botrytis*)

Snap Bean Diagnostic Guide *adapted from the* **Soybean Problem Diagnostic Guide***, IPM Scout Manual, Purdue University, 1978.*

Scouting Calendars

UW Extension

Snap Bean Insect Pests in Wisconsin



Snap Bean Disease Scouting Table

Diseases	Temperature	Climate	Occurrance
Aphanomyces Root Rot	68-82ºF	wet soils	pre-emergence—harvest
Pythium Root Rot	depends on species	excessive moisture	pre-emergence—harvest
Rhizoctonia Root Rot	excessive moisture	pre-emergence—harvest	
Bacterial Brown Spot	60-90ºF	excessive rainfall, long periods of leaf wetness	seedling—harvest
Common Blight	75-90ºF	high humidity or free moisture	seedling—harvest
Fusarium Root Rot	72-82ºF	dry	seedling—harvest
Halo Bight	60-68ºF	humid	seedling—harvest
Rust	50-75ºF	high humidity	seedling—1st flower
Bean Yellow Mosaic Virus		weather that favors aphids	1st flower bud—harvest
White Mold	68-77ºF	continuous leaf wetness (48-72 hrs)	1st flower bud—harvest

Bean Aphid

Scientific Name: *Aphis fabae*
Order: Homoptera
Family: Aphidae

General Information

Biological Description

Adult bean aphids are dark green to sooty black, 1/12 inch long, and soft bodied with or without wings. Immature nymphs are green, spotted and very small with black cornicles. Aphids congregate in large numbers on the succulent new growth, usually on the lower leaf surface.

Economic Importance

Bean aphids are rarely a pest of snap beans in Wisconsin.

Life Cycle

Bean aphids overwinter as eggs on woody shrubs (Euonymous, Viburnum) and move to their summer host plants by June. Populations continue to build throughout the summer, with females giving birth to live young continuously and a single generation being completed in 10 days under ideal conditions. In fall, winged reproductive forms are produced which migrate to winter hosts, mate, and lay eggs.

Host Range

Winter hosts are Euonymus and Viburnum. "Summer forms" of bean aphid attack various vegetables including beans, carrots, lettuce, spinach, ornamentals, and weeds such as wild dock and pigweed.

Damage/Symptoms

Infected plants may look stunted, or wilted with yellowish foliage. Aphids congregate on succulent new growth and cause curled or shrivelled leaves. Black "dust like" sooty mold may appear and grow on the honeydew excreted by the aphids. Bean aphids can cause indirect damage by the transmission of bean mosaic virus with winged forms being most effective in disease transmission.

Scouting Procedure and ET

No thresholds have been established. Look for small "hot spots" of bean aphid scattered throughout the field. Because of the spotty nature of infestations in the field, a number of plants in several areas of the field should be examined for aphids. Check 15 consecutive plants (terminals only)/sample unit and rate the plants as infested or uninfested. Given the huge reproductive potential of aphids, an infestation level of 5-10% would indicate a potentially damaging infestation. Repeated checks at weekly intervals would indicate the need to treat.

Integrated Control

Non-Chemical Control

Natural Control: Predators such as ladybird beetle adults and larvae, green lacewing larvae, syrphid fly larvae, and several parasitic wasps all help reduce aphid numbers. Heavy rains help dislodge aphids from the plant and, during periods of high humidity, fungal diseases may greatly reduce populations. The remarkable reproductive capacity of the aphid normally overcomes the effects of natural controls however.

Cultural Control: No effective cultural controls are known.

Chemical Control

Commercial: Acephate, diazinon, dimethoate, malathion, and naled are registered for the control of bean aphids. Refer to the product label for specific application instructions and precautions.

Homeowner: If infestation occurs treat with Malathion. Insecticidal soaps will also reduce populations.

Insecticide Resistance: None.

References

R. H. Davidson and W. F. Lyon (1979) Insect Pests of Farm, Garden, and Home. 7th edition. John Wiley & Sons, New York 596 pp.

C. L. Metcalf and R. L. Metcalf (1993) Destructive and Useful Insects, their Habits and Control 5th Ed. McGraw-Hill Book Co., New York.

Black Cutworm

Scientific Name:
Agrotis ipsilon

Order: Lepidoptera
Family: Noctuidae

General Information

Biological Description

Black cutworm larvae generally feed at, or below the ground surface at night. It is an active feeder on young foliage or stem tissue and will cut off many young seedlings in an evening. The large, greasy, dark gray larvae will curl up into a tight C-shape if disturbed. Mature, 6 th instar larvae, are 1.5" long and have a grainy texture. Adult cutworms are gray moths which have a series of distinctive dark markings on their forewings and lighter colored hindwings. The black cutworm larvae are easily confused with other cutworms, but generally damage crops earlier in the season than other species. This cutworm may be problematic to the home gardener.

Economic Importance

The black cutworm is an occasional seed and seedling pest of snap beans.

Life Cycle

Moths that appear in late May have migrated to Wisconsin from other states. Overwintering black cutworms in Wisconsin are rarely abundant enough to cause significant damage. Female moths lay hundreds of eggs either singly or in clusters. Oviposition is typically concentrated on low-growing vegetation such as chickweed, curly dock, mustards, or plant residue from the previous year's crop. As a result, heavy spring weed growth, newly broken sod, previous crop and plant debris all increase the risk of black cutworm infestations. Generally, black cutworm moths will not lay eggs in fields that have already been planted. Young larvae (less than one-half inch in length) feed above ground. Larger larvae feed at, or just below the soil surface, although in fields with very dry soil conditions, the larvae may be found 2-3 inches deep. Cutting stage larvae may take as long a s 34 days to pupate at temperatures of 60 degrees F, while only 12 days may be required at temperatures of 75 degrees F. There are three generations per year. It is the first generation which is active during May and June that causes the most damage.

Host Range

Black cutworm larvae attack a wide variety of vegetable and field crops, especially in the seedling stage.

Environmental Factors

Excessive rainfall may disrupt egg-laying. Flooding may force larvae to the soil surface during the day where they are attacked by parasites and predators.

Damage/Symptoms

Larvae tend to feed at night or on cloudy days and hide in the soil or under foliage during the day. Newly hatched larvae are unable to chew entirely through the leaf surface resulting in a "window pane" appearance on the leaves. As the black cutworm larvae grow, their feeding damage becomes pinholes in the leaves and often complete defoliation of the leaves. Alternately, young variegated cutworm larvae feed on the terminal growth while older larvae feed near the ground. Once the larvae reach the "cutting" stage, they are ½ inch long and cut the stem at, or just below the soil surface. One large larvae may destroy several plants in one evening. The larvae will often pull the stem of the severed plant into their subterranean burrows. This type of injury is common during extended periods of dry weather. One large larvae may destroy several plants in one evening. The larvae will often pull the stem of the severed plant into their subterranean burrows.

Scouting Procedure/ET

Timely detection is critical if post-emergent insecticidal treatment is to be effective. Blacklight and pheromone traps are useful for monitoring moth activity but do not correlate well with predictions of whether damage will occur as well as when or where damage may be expected. Shake five foot sections of two adjacent rows into the furrow and count the larvae on the soil surface. Divide the number of larvae counted by five. The resulting number is the number of worms per foot row. Repeat in several locations within the field since infestations may be restricted to certain areas. Spot treat if possible when 2 larvae/1 foot of row are observed.

Integrated Control

Non-Chemical Control

Natural Control: A number of braconid parasites and predaceous ground beetles help keep cutworm numbers down. Cutworms are most problematic in low, wet, grassy areas. Cutworms serve as prey for birds.

Cultural Control: Since female moths prefer to lay eggs in grassy situations, keeping grassy weeds controlled will lessen the possibility of problems. Avoid planting susceptible crops in low wet areas or in rotations following sod. Coffee cans or other cylindrical barriers will provide adequate protection to small plantings.

Biological Control: Several species of tachinids, braconids, and ichneumonids help reduce populations.

Chemical Control

Commercial: Spot treat with carbaryl or esfenvalerate when numbers exceed two larvae per row foot. Refer to the product label for more information on specific application instructions and precautions.

Homeowner: Apply Sevin bait if extensive foliage feeding observed.

I***nsecticide Resistance:*** None.

References

R. H. Davidson and W. F. Lyon (1979) Insect Pests of Farm, Garden, and Home. 7th Ed. John Wiley & Sons, New York 596 pp.

C. L. Metcalf and R. L. Metcalf (1993) Destructive and Useful Insects, their Habits and Control 5th Ed. McGraw-Hill Book Co., New York.

Cabbage Looper

Scientific Name: *Trichoplusia ni*
Order: Lepidoptera
Family: Noctuidae

General Information

Biological Description

The cabbage looper adult is a grayish-brown, night -flying moth with wing span of 1.5". The mottled brown forewings are marked near the middle with a small silver-white figure-8 or letter-Y. Hindwings are uniformly brown. The caterpillar (larva), is called a looper because of the way it arches its body while moving. Mature larvae are up to 1 1/2 inches long, have a greenish body which tapers at the head end with a thin white line along the sides and two lengthwise white lines on the middle of the back. There are three pair of prolegs at the distal end of the abdomen. Eggs are small, round, and white in color. They are laid singly under the cabbage leaf near the edge. Pupae, which are enclosed in a loosely woven silken covering, are brown and 1/2-3/4 inches long.

Economic Importance

The larvae attack and feed on the leaves between the large veins and midribs. Most damage is caused by the second generation larvae in August. Damage is seldom severe or economically important in Wisconsin.

Life Cycle

Cabbage loopers probably do not overwinter in large numbers in Wisconsin, but migrate in from the south from mid-July through September. Overwintering pupae give rise to the 1st generation adults in the spring. White eggs are laid singly on the lower leaf surface in June. Larvae mature through 5 successively larger instars taking 4-5 weeks before leaving the plant to pupate. Adults emerge in 10-14 days, mate, and lay eggs which give rise to the second generation. Second generation cabbage loopers cause the most damage in August and September.

Host Range

Host plants include beets, cole crops, celery, lettuce, mint, peas, potato, spinach, and tomato.

Damage/Symptoms

The larvae attack and feed on the leaves between the large veins and midribs. The most damage is caused by the second generation of larvae in August. Damage is seldom severe or economically important.

Scouting Procedure/ET

Loopers and other lepidopterous larvae are easily scouted by shaking plants to dislodge larvae onto the ground or drop sheet. Make counts in 10-20 foot sections of row scattered throughout the field. Thresholds have not been determined, but a total larval count (cutworms, loopers, etc.) of 2/foot of row during susceptible stages (flowering) will usually result in greater than 20% defoliation which may reduce yields.

Integrated Control

Non-Chemical Control

Natural Control: Natural controls are frequently quite effective in holding looper populations down. An egg parasite (trichogramma), several larval parasites, and an egg-larval-pupal parasite (copidosoma) may become numerous. Several general predators attack the egg and larval stages. Late in the season, an NPV virus and fungal disease may become epidemic. These virus and fungal parasites are particularly effective during Wisconsin's cool damp falls.

Cultural Control: Spring plowing of debris and clean culture are good insurance against potentially overwintering cabbage looper pupae.

Biological Control: There ar no commercially available biological control agents which are cost effective to use to reduce looper populations.

Chemical Control

Commercial: Treat when numbers exceed 2-4 larvae per row foot. Acephate, Bacillus thuringiensis, esfenvalerate, methomyl and naled are registered for control of cabbage loopers. Refer to the product label for specific application instructions and precautions.

Homeowner: Hand pick larvae or treat with Dipel to promote beneficial insects. Chemical treatment is seldom necessary.

Insecticide Resistance: None.

References:

R. H. Davidson and W. F. Lyon (1979) Insect Pests of Farm, Garden, and Home. 7th Ed. John Wiley & Sons, New York 596 pp.

C. L. Metcalf, W. P. Flint and R. L. Metcalf (1962) Destructive and Useful Insects, their Habits and Control 4th Ed. McGraw-Hill Book Co., New York.

Common Stalk Borer

Scientific Name: *Papaipema nebris*
Order: Lepidoptera
Family: Noctuidae

General Information

Biological Description

The larvae are purplish-brown with longitudinal, off-white stripes running the length of their body. There is a purplish saddle band located behind a yellow head. They range from ½ to 1 ½ inches long and are extremely active when disturbed. Adult moths have dark grey-brown forewings with numerous small, white spots. The wingspan is approximately 1 1/4 inches.

Economic Importance

The common stalk borer is a rare pest of snapbean in Wisconsin but may infest field edges.

Life Cycle

Adult female stalk borers lay up to 2,000 eggs in late August and September in grassy weeds, ragweed, pigweed, curly dock, burdock. The eggs overwinter and hatch in early spring (mid-April to early May). The tiny caterpillars can cause pinhole feeding in the leaves of seedling corn in late May in southern Wisconsin. As the larvae grow, the grass stems become too small and by late June larvae begin to migrate from the grassy field borders into the border rows of adjacent crops. Larvae are fully grown in late August and may bore into many stems before pupating in the soil. Adults emerge 2-6 weeks later (late August) and seek grassy areas in which to oviposit. There is one generation/year.

Host Range

The host range of the common stalk borer is comprised of over 170 species. This insect attacks virtually any plant large enough for it to bore into, including all beans, corn, and potatoes.

Environmental Factors

Poor weed control will favor outbreaks of this pest.

Damage/Symptoms

Larvae bore into the stem of beans 2-8 inches above the soil line. Once inside the stem, they begin to burrow up and down within the plant, causing the plant to wilt and die above the point of feeding. A small, round hole may be seen at the site of entry. If plants suspected of being infested with common stalk borer larvae are cut, the larva will be present. Damage is usually confined to the margins of the field.

Scouting Procedure/ET

Damage may appear severe on field margins, but on a whole field basis usually involves less than 2% of plants. Record number of wilted plants/100 throughout the field to determine an average. No thresholds have been established, but early treatment of field edges may be necessary if 5% of the plants are infested and larvae are small.

Integrated Control

Non-Chemical Control

Natural Control: Populations seem to build and decline in 4-6 year cycles but the reasons for this are not understood.

Cultural Control: Cultural control is by far the most important control for this pest. Poor weed control during the previous year provides numerous oviposition sites and can result in extensive patches of crop damage the following year. Keep fall weeds, especially grasses, controlled to prevent egg laying. Mowing fence rows in mid-August may also help.

Biological Control: There are no commercially available biological control agents which are cost effective to use to reduce stalk borer populations.

Chemical Control

Commercial: Because this is an infrequent pest of snapbeans, chemical control is only recommended on field edges.

Homeowner: Cultural controls are recommended.

Insecticide Resistance: None.

References

R. H. Davidson and W. F. Lyon (1979) Insect Pests of Farm, Garden, and Home. 7th Ed. John Wiley & Sons, New York 596 pp.

C. L. Metcalf and R. L. Metcalf (1993) Destructive and Useful Insects, Their Habits and Control 5th Ed. McGraw-Hill Book Co., New York

Corn Earworm

Scientific Name: *Helicoverpa zea*
Order: Lepidoptera
Family: Noctuidae

General Information

Biological Description

Adult corn earworms are grayish-brown moths with a wing span of about 1.5". The front wings are marked with dark-gray irregular lines and with a dark area near the wing tip. The hind wings are white with dark spots or areas along the margins. The olive-brown larvae generally have 3 or 4 dark stripes along their back, and measure 2" long when mature. The head is yellow and not spotted. The 1/32" yellowish, sculptured, hemispherical eggs are laid singly on the foliage or corn silks.

Economic Importance

Corn earworms can be a periodic pest of snapbeans if they are present during the period between bloom and 5 days prior to harvest.

Life Cycle

Few corn earworms overwinter in Wisconsin, and most migrate annually from the South into the state, infesting sweet corn fields, vegetable crops and a wide range of crops. Corn earworms mainly overwinter in the South as pupa buried in the soil. Pupae complete development in the spring. Adults emerge in early May and begin their northward migration. The moths fly mainly at dusk or during warm cloudy days. Eggs are laid individually and each fertilized female can deposit up to 1000 eggs during her life span. Larvae emerging from the eggs immediately begin feeding. After approximately two weeks, the larvae drop to the ground to pupate. Approximately two weeks later, adult moths emerge and work their way to the soil surface. Development from egg to adult requires about 30 days in midsummer. In the North, there are 2 generations per year. In Wisconsin, first generation adults usually appear in June. The more damaging second generation appears in late August to early September. The smaller early summer generation generally does little damage on snapbeans which have not reached a susceptible stage when moths arrive.

Host Range

Beans, lettuce, peppers, sweet cron and tomatoes all serve as hosts to the corn earworm.

Damage/Symptoms

Corn earworm larvae feed on both leaves and buds, producing holes in the plant tissue. In addition, larvae may also pose a contamination problem in snapbeans grown for processing.

Scouting Procedure/ET

Corn earworms are easily monitored with the use of Hartstack pheromones traps or blacklight traps. Traps should be checked daily beginning in July. If less than 5 moths /blacklight trap or 10/ pheromone trap, treatment is unnecessary. If 5/blacklight trap or 10/pheromone trap are present, vulnerable beans (30-7 days before harvest) should be treated. If 25/blacklight trap or 100/ pheromone trap are present, a reinfestation flight is occurring and susceptible beans should be treated on a 5-7 day schedule. If over 100/blacklight trap or 500/pheromone trap are present, a migration flight is occurring and susceptible stage beans should be treated on a 5-7 day schedule using high rates of an effective material.

Integrated Control

Non-Chemical Control

Natural Control: Corn earworm larvae will cannibalize other larvae on the same plant. The eggs are parasitized by Trichograma wasps, and preyed upon by the flower bug, Orius tristicolor. Larvae are also parasitized by a number of chalcid and braconid wasps.

Cultural Control: Avoid planting snapbeans next to sweet corn.

Biological Control: There are no commercially available biological control agents which effectively reduce corn earworm populations.

Chemical Control

Commercial: Carbaryl, esfenvalerate, and methomyl are labeled for the control of the corn earworm in beans. Carbaryl can be toxic to honey bee colonies, do not use this product if neighboring crops are in bloom. Refer to the product label for more information on specific application instructions and precautions.

Homeowner: Apply Sevin or Dipel if larvae are numerous. Alternatively, larvae can be handpicked and destroyed.

Insecticide Resistance: None.

References

R. H. Davidson and W. F. Lyon (1979) Insect Pests of Farm, Garden, and Home. 7th Ed. John Wiley & Sons, New York 596 pp.

C. L. Metcalf and R. L. Metcalf (1993) Destructive and Useful Insects, Their Habits and Control 4th Ed. McGraw-Hill Book Co., New York.

Foster, R. E. and B. R. Flood. (1994) Midwest Vegetable Insect Management. Purdue University Agricultural Experiment Station. West Lafayette, IN.

European Corn Borer

Scientific Name: *Ostrinia nubilalis*
Order: Lepidoptera
Family: Pyralidae

General Information

Biological Description:

Eggs are white, overlap like fish scales, and are deposited on the lower leaf surface of leaves and near the midvein. There can be as many as 30-40 eggs in each mass. As they develop, the eggs change to a creamy color. Just before hatching, the black heads of the larvae become visible inside each egg. This is referred to as the black-head stage and each egg reaching this stage usually hatches within 24 hours. Full grown larvae are 3/4-1 inch in length and grey to cream-colored with numerous dark spots covering the body. The pupae are brown, 3/4 inch long and cigar-shaped with segmentation evident on one-half of the body. The adults are nocturnal, straw-colored moths with a 1 inch wing span. Males are slightly smaller and distinctly darker than females.

Economic Importance:

The European Corn Borer is a sporadic pest of potatoes in Wisconsin especially in the southern 1/3 of the state. In years when the first generation of the European corn borer adults occurs early (late May), the preferred egg-laying sites in corn are not yet available and ovipostition can be heavy in potatoes.

Life Cycle:

The European corn borer overwinters as mature 5th instar larvae in corn stalks and stems of weedy hosts. Spring development begins when temperatures exceed 50 degrees F. Pupation occurs in May with the first moths emerging in early June in southcentral Wisconsin. Peak emergence occurs in mid-June at 600 degree days (base 50). Adult moths are nocturnal and spend most of their daylight hours in sheltered areas along field edges. Female moths lay egg masses in the evening. The eggs hatch in 3-7 days depending on the temperatures and young larvae feed on leaves and in the midrib of the leaves for 5-7 days (125 DD_{50}) before boring into stems. Boring usually begins with the second and third instars. The larvae pass through five instars and complete their feeding and development while boring inside stems. The earliest larvae to mature embark upon a 12 day pupal period within the stalk after which time the adult moths emerge. This begins the second generation. Late-maturing larvae go into diapause (a pause in development) and overwinter. Second generation moths peak in mid-August when approximately 1700 DD_{50} have been reached and may lay eggs in potatoes or other crops. All mature 2nd generation larvae enter diapause in late September and October and overwinter. In seasons with unusually warm spring and summer temperatures, some of the second generation larvae will pupate, emerge as moths and lay eggs for a late-season, third generation of larvae. These larvae do not have a chance to become fully grown before cold weather arrives and ultimately will perish.

European Corn Borer Development (DD base 50)

First Generation	Accumulated DD
First moth	375
First eggs	450
Peak moth flight	600
Larvae present	800-1000

Host Range:

Corn borers attack over 200 different kinds of plants including corn, vegetables, field crops, flowers and some common weeds. Serious damage may occur on sweet corn, peppers, snap beans and potatoes.

Environmental Factors:

Cool weather and drought delay spring insect development due to the desiccation of eggs and young larvae. Conversely, warm weather and moisture may accelerate insect development. Excessive heat and drought in spring may cause increased mortality of all stages. The number of eggs laid is affected by the availability of drinking water of which, dew is considered an important source. Heavy rainfall will decrease moth activity and drown newly-hatched larvae in whorls and leaf axils, or even wash them from the plant.

Damage/Symptoms:

When the European corn borer attacks potatoes, larvae can feed on foliage as well as inside stems. Larval feeding on the lower leaf surface results in small feeding scars when all of the leaf tissue except the transparent upper epidermis is eaten. Stems which sustain boring damage show an entry hole, 1/8 inch in diameter, typically surrounded by frass. Above the entry hole the stem may be wilted and the leaves flagged. Older, larger larvae create larger entry holes than do smaller larvae, and tissue around older entry holes is often discolored, whereas tissue is usually still healthy around recently-made holes. Most damage is caused by larvae which develop from eggs laid by moths flying in June. Secondary bacterial infection may invade the stems and cause stalk death.

Scouting Procedure/ET:

Egg mass counts are made to detect damaging levels of oviposition. The best procedure for determining when damaging levels of oviposition are likely is to operate a black light trap in the field and count trapped moths daily. Adult European corn borer moths congregate in dense weedy areas on field edges prior to egg laying. Traps should be operated in the grassy edge or corner of the field and should be far enough from buildings to avoid interference. Catches will vary with location, but when an increase in catch occurs on 3 consecutive nights the flight is severe enough to warrant treatment on susceptible crops. If moth flights are greater than 25 moths/trap/night anytime during the June flight, oviposition may be high enough to cause economically important levels of crop damage. By referring to light traps in other fields or areas, and by following the WDATCP Cooperative Pest Survey Bulletin of statewide black light trap catches, growers can follow the general population and predict local areas more effectively.

Degree day accumulation may also be used to predict moth flights. Using a base temperature of 50ºF, peak flights will occur at 600 DD_{50} (typically in mid-late June) and 1700 DD_{50} (mid-August). Action sites along field edges can be walked regularly to gauge the level of European corn borer populations close to an individual field. For the first generation, scouting should begin at 500DD_{50} and continue through 700DD_{5} or until egg counts drop off. Sample for egg masses from the mid to lower portion of the plant by examining the lower leaf surface of 25 leaves per sample site. If greater than 4% of the leaves (one out of 25 leaves) are infested with eggs as a field average, control is recommended. Because Norgold, Norkota and Norchip varieties are particularly susceptible to damage, control is recommended if greater than 2% of the leaves are infested with egg masses.

Integrated Control

Non-Chemical Control:

Natural Control: Weather conditions greatly influence European corn borer survival, particularly during the egg stage and while young larvae are feeding on the leaves. Heavy rains wash the egg masses and young larvae off the plants and thus can greatly reduce borer numbers. In addition, very hot, dry weather causes desiccation of the eggs and young larvae. These climatic variables will kill 22-68% of freshly hatched larvae. Predators, parasites, and diseases also take their toll on European corn borer populations, however, there is no way to predict the impact of these factors.

Cultural Control: Plowing under crop stubble in the fall, thereby destroying overwintering larvae, has long been an effective method of reducing borer populations. This is especially important in nearby corn fields, where the majority of corn borers are produced. European corn borer moths rest in weedy, grassy areas at field edges during the day and then fly into nearby crops to lay eggs at night. Cleaning up such areas around fields can reduce borer pressure. Certain varieties of potatoes are annually attacked by the European corn borer and may result in economic damage. Norgold, Norchip, and Norkota are attractive to oviposition, with Norgold and Norkota being especially susceptible to damage. Russet Burbank can sustain moderate to heavy damage without yield reduction, although quality may be affected.

Biological Control: None.

Chemical Control:

Commercial: Guthion, Sevin, Furadan, Asana, Ambush and Pounce are all registered for the control of European corn borers in potatoes. Foliar insecticides should be applied 5-7 days after heavy egg deposition based on thresholds. It is essential to obtain good plant coverage. If oviposition continues, a second application may be necessary. Two applications are often necessary for Norgold and Norkota varieties. The first spray should be made one week after initial egg deposition and the second about one week later. Refer to the product label for specific recommendations and precautions.

Homeowner: Damage is minimal and control is unnecessary.

Insecticide Resistance: None.

References:

C.L. Metcalf & R. L. Metcalf (1993) Destructive and Useful Insects, Their Habits and Control 4th Ed. McGraw-Hill Book Co., New York.

S. E. Rice Mahr, J. A. Wyman, E. B. Radcliffe, C. Hoy and D. W. Radsdale. 1995. Potato: Chapter 5 in Midwest Vegetable Insect Management. R. Foster and B. Flood Eds.

Green Cloverworm

Scientific Name: *Plathypena scabra*
Order: Lepidoptera
Family: Noctuidae

General Information

Biological Description

Larvae are thin, looping, pale green caterpillars with two narrow white stripes along each side of body. Fully developed larvae may be up to 1 1/2 inches long with 3 pair of prolegs. Adult moths are dark brown with black-spotted or mottled forewings. The wingspan is 1 1/4 inch wingspan.

Economic Importance

The caterpillar of this moth is a leaf feeder which rarely builds up to damaging levels on beans in Wisconsin.

Life Cycle

Green cloverworms overwinter as pupae or adults, becoming active by early May. Eggs are laid singly on lower leaf surface of host plants. Eggs hatch in 5 days, and larvae feed for 3 weeks before leaving the plants to pupate in the soil. Adult moths emerge within three weeks. There are normally two generations per year in Wisconsin.

Host Range
Alfalfa, clover, beans, strawberries, raspberries, and many weed species are attacked.

Damage/Symptoms
Green cloverworms and their damage are normally uniformly distributed within fields, becoming evident in late June. Larvae are general leaf feeders and heavily infested fields will take on a ragged appearance. Holes may be drilled in pods when these are present.

Scouting Procedure/ET
To estimate populations count the number of larvae per linear foot of row in several areas of the field by shaking larvae onto a drop sheet. Populations of 2 row feet are considered damaging.

Integrated Control
Non-Chemical Control
Natural Control: A fungal disease, two species of parasitic wasps and one fly parasite kill most larvae before they mature and cause economic damage. These biocontrol factors are considered to be responsible for the sub-economic populations seen most years in Wisconsin.

Cultural Control: No effective cultural controls have been described.

Biological Control: There are no commercially-available biological control agents which are cost effective to reduce green cloverworm populations.

Chemical Control
Commercial: Acephate, Bacillus thuringiensis, esfenvalerate, methomyl, and naled are recommended for cloverworm control. Consult the product label for more information on specific application instructions and precautions.

Homeowner: Green clover worm control is rarely necessary. Ifdamaging populations are detected, treat with Bacillus thuringiensis (Dipel, Thuricide, etc.).

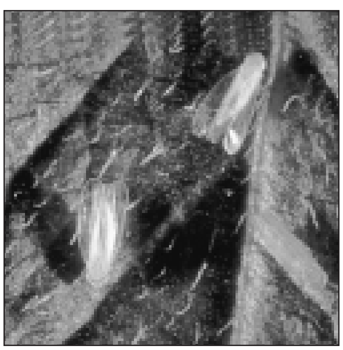
Insecticide Resistance: None.

References
R. H. Davidson and W. F. Lyon (1979) Insect Pests of Farm, Garden, and Home. 7th Ed. John Wiley & Sons, New York 596 pp.

C. L. Metcalf and R. L. Metcalf (1993) Destructive and Useful Insects, their Habits and Control 5th Ed. McGraw-Hill Book Co., New York.

Potato Leafhopper

Scientific Name: *Empoasca fabae*
Order: Homoptera



General Information
Biological Description
Potato leafhopper, Empoasca fabae. Order:Homoptera. Family: Cicadellidae. Most serious insect pest of southern and central Wisconsin potatoes. Adults are small, wedge-shaped, pale green insects with whitish spots on the head and thorax. They have piercing/sucking mouthparts. Adults are extremely active; jumping, flying or crawling sideways or backwards when disturbed. Nymphs (immatures) are similar in appearance to the adults. They are yellow-green in color and do not have fully developed wings. Nymphs are less active but crawl rapidly, often seeking to regain the lower leaf surfaces when dislodged.

Economic Importance
The potato leafhopper is one of the most serious pests on snap beans in Wisconsin.

Life Cycle
Potato leafhoppers do not survive the Wisconsin winter. Populations build up on legumes early in the year in isolated areas of the Gulf States and migrate northward in April and May on warm southerly winds. The first migrants, which are primarily females, reach Wisconsin in mid- to late May. Large influxes of migrants occur in June and early July causing populations to increase rapidly and seemingly 'explode' overnight. White eggs are laid on susceptible crops by insertion into stems or large leaf veins. Each female lays approximately 3 eggs/day and oviposition typically lasts about one month. Eggs hatch in 7-10 days. Nymphal development involves 5 successively larger instars and takes l2-15 days. Migrating adults die by July. First generation offspring mature in late July and the second generation matures in early September. There are normally 2 generations per year in Wisconsin.

Host Range
Potato leafhoppers feed on and may damage a wide range of host plants including potatoes, all types of beans, soybeans, alfalfa, eggplant, strawberries, rhubarb, clover, apples, dahlia, and other bedding plants and many weed species.

Damage/Symptoms
Both nymphs and adults feed by inserting their piercing/sucking mouthparts into the vascular tissue of the plant and extracting sap. Damage is caused to both xylem and phloem tissues. Indirect damage results from the introduction of a toxin with the saliva during feeding. General symptoms include stunted plants, with chlorotic foliage which curls upward at the margins. Early symp-

toms include triangular, brownish spots at the leaflet tip or at the leaf margins near veinlets. Browning progresses inward from the margins and leaf margins become dry and brittle. Often, only a narrow strip of green tissue remains along the midveins. The burned appearance of the foliage is where the term "hopperburn" is derived. Symptoms of feeding injury begin on older foliage and move upward. Pre-mature death of untreated vines causes severe yield reduction. Damage may be more severe in hot, dry years. Nymphs are more injurious than adults. Sustained feeding on snap beans may cause blossom blast resulting in poor, prolonged pod set and reduced yields.

Scouting Procedure/ET

Take 25 sweeps per sample site, with at least 10 sample sites per 100 acres. Sites should be scattered throughout the field. Nymphs are less mobile and are best scouted by sampling leaves. Carefully turn over 25 leaves per sample site and count nymphs. Select leaves from the middle portion of the plant and use at least 10 sample sites per 100 acres. If counts exceed 1 leafhopper adult per sweep or 1 nymph per 10 leaves, then control measures are recommended. If plants are younger than the 2 true leaf stage, reduce thresholds to 1 adult per two sweeps. Nymphs are unlikely to be present in seedling beans and therefore need not be scouted.

Integrated Control

Non-Chemical Control

Natural Control: No natural mortality factors of significance.

Cultural Control: Healthy, vigorously growing vines will withstand damage more effectively than stressed plants. Irrigation and cultural practices which favor crop health are recommended. Infestations are likely to be more severe in crops planted adjacent to alfalfa, particularly after alfalfa is cut in mid-summer.

Chemical Control

Commercial: Acephate, azinophos-methyl and carbaryl are registered for the control of the potato leafhopper on snap bean.

Homeowner: Carbaryl applied when populations reach 5 adults or 2 nymphs/plant will provide adequate control. Aphid populations may be increased with repeated carbaryl applications.

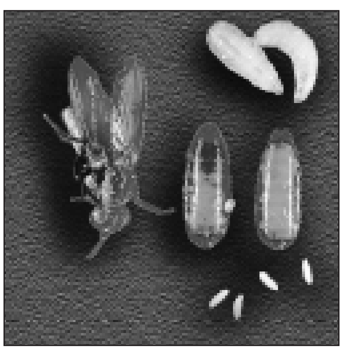
References

R.H. Davidson and W.F. Lyon (1979) Insect Pests 7th Ed. of Farm, Garden, and Home. John Wiley & Sons, New York. 596 pp.

C.L. Metcalf & R.L. Metcalf (1993) Destructive and Useful Insects, Their Habits and Control 5th Ed. McGraw-Hill Book Co., New York. 1087 pp.

Seed Corn Maggot

Scientific Name: *Hylemya cilicrura*
Order: Diptera
Family: Anthomyiidae



General Information

Biological Description

The yellowish-white larvae are typical fly maggots, 1/5 inch long when fully grown, cream colored, legless and wedge-shaped with the head end sharply pointed. Pupae are brown, 1/5 inch long and cylindrical in shape, and rounded on both ends. Adults resemble miniature houseflies; they are dark grey, 1/5 inch long and their wings are held overlapped over their bodies while at rest. Adult seed corn maggots are smaller than cabbage and onion maggots, with whom they are easily confused. Eggs are about 1/32 of an inch in length, oval, and white.

Economic Importance

The seedcorn maggot is a perennial pest on beans in Wisconsin.

Life Cycle

The seedcorn maggot overwinters as pupae in the soil. Peak adult emergence from overwintering pupae occurs anytime from early to mid-May when degree day accumulations reach 200 DD_{39}. Newly emerged adults may be seen flying in large numbers over recently tilled fields. Adults mate within 2-3 days of emergence and females lay eggs in soil with high organic matter or near seeds and seedlings of a wide variety of plants. Egg hatch occurs in 2-4 days. Larval feeding, development, and pupation all occur below ground and the subsequent generation of adults appears 3-4 weeks later. This sequence of events is repeated and 3-5 generations of seedcorn maggots may occur during a season.

Host Range

Seeds and seedlings of most vegetable crops including beets, cabbage, corn, cucumbers, peas, radishes, squash, turnips, and kidney, lima and snap beans.

Environmental Factors

Cool, wet weather favors this insect while hot, dry weather is detrimental to its survival. Therefore, the seedcorn maggot is more likely to be a problem during the spring and early summer than later in the season. Cool, wet springs and doughty conditions may delay seed germination and lead to increased damaged by the seedcorn maggot. The application of livestock manure and incorporation of vegetation prior to egg laying makes fields more attractive to the female flies. Tillage of live plant material is more attractive than tillage of dead plant residue. The decomposition of the green vegetation may produce compounds that attract the files.

Damage/Symptoms

Seedcorn maggot larvae feed in the cotyledons and plumules and in the below-ground hypocotyl tissue of seedlings, resulting in a variety of damage symptoms. Larval feeding in germinating seeds can be severe enough to cause plant death before seedling emergence. Therefore, poor germination or poor plant stands may indicate a seedcorn maggot problem. Plants which survive maggot damage to the seed often have holes in the first pair of true leaves or no leaves at all (snakehead seedlings). Even minor amounts of damage to the first pair of true leaves can cause delayed maturation and a reduction in yield. Occasionally, larvae also feed in the below-ground hypocotyl tissue. Plants severely attacked in this manner will turn yellow and wilt.

Scouting Procedure/ET

Seedcorn maggot damage cannot be detected until it is too late to take control actions. Therefore, economic thresholds for this insect are not useful and insecticides are applied at planting as a protective measure. The following scouting procedure can be helpful in determining fly-free periods during which to plant. In early April, 3-4 yellow plastic dishpans filled with soapy water should be placed along a field edge (100 ft intervals). Flies trapped in the water should be removed every 4-6 days at which time fresh soapy water should be added. Records of the number of flies trapped will indicate when fly numbers are building up or tapering off. Forecasting the appearance of generations can be done by accumulating degree days starting when the ground thaws in the spring. Degree days are calculated each day using the formula ((maximum temperature + minimum temperature)/2)-39. A running total of day degrees is kept and peak emergence of the first three generations will occur when totals of DD_{39} = 200, 600, and 1000 respectively, have been reached.

Integrated Control

Non-Chemical Control

Natural Control: Naturally occurring fungal diseases occasionally will greatly reduce seedcorn maggot numbers significantly, particularly when flies are abundant and relative humidity is high. During a fungal epidemic, dead or diseased flies can be seen clinging to the highest parts of plants along field edges. Predaceous ground beetles, which eat seedcorn maggot eggs, larvae, and pupae, can also be important in reducing maggot numbers. Because these soil-inhabiting beetles are susceptible to insecticides, broadcast soil insecticide treatments should be avoided whenever possible.

Cultural Control: Since the seedcorn maggot is attracted to decaying organic matter, fields where animal or green manure has recently been applied should not be planted. Plant seeds as shallow as feasible to speed germination. Any procedure which promotes fast germination and seedling growth will reduce chances of maggot damage. Therefore, beans should not be planted during cool weather or when soil temperatures are below 50°F. In addition, home gardeners can soak seeds in water for about 2 hours prior to planting to promote fast germination and seedling growth. It is also possible to avoid seedcorn maggot damage by planting beans during fly-free periods that occur between generations of flies (see Scouting/ET).

Chemical Control

Commercial: Insecticides labeled for the control of seedcorn maggot in beans provide preventative treatments for both an option for seed treatment as well as one for soil application at the time of planting. Currently, there are no insecticides registered for treatment once an outbreak has occurred. Chlorpyrifos and diazinon may be applies as a seed treatment. Fonofos is recommended as a broadcast treatment which is incorporated into the soil prior to planting. Phorate granules should be applied in a band over the row at planting time. Refer to the product label for more information on specific application instructions and precautions.

Homeowner: Small amounts of seed can be treated by shaking 1/4 teaspoon of Diazinon seed treatment with the seed prior to planting.

Insecticide Resistance: None.

References

R.H. Davidson & W.F. Lyon (1979) Insect Pests 7th Ed. of Farm, Garden, and Home. John Wiley & Sons. New York 596 pp.

C.L. Metcalf & R.L. Metcalf (1993) Destructive and Useful Insects, Their Habits and Control 5th Ed. McGraw-Hill Book Co., New York.

Tarnished Plant Bug

Scientific Name: *Lygus lineolaaris*
Order: Hemiptera
Family: Miridae

General Information

Biological Description

Adults 1/4 inch long and half as broad. They are dorsiventrally flattened with a small head. Coloration is variable, but generally brown with splotches of white, yellow, reddish-brown and black. There is a clear yellow triangle tipped with a smaller black triangle on the posterior end of the abdomen. Nymphs range in size from 1/25 inches to 3/16 inches long. Coloration is variable, ranging from mottled black and white bands on a dull green base to light green with black flecks. Nymphs also lack the wings which are characteristic on the adults.

Economic Importance

The tarnished plant bug is a moderate pest of snap beans.

Life Cycle

Tarnished plant bugs overwinter as adults under leaf mold, stones, tree bark, and among the stubble of clover and alfalfa. Adults begin to emerge in late April to early May. After feeding for a few weeks, they migrate to various herbaceous weeds, vegetables, and flowers where eggs are inserted into the stems, petioles, or midribs of leaves. Eggs hatch in about 10 days. There are five nymphal instars which require 20-30 days to complete. Second generation adults begin to emerge in late June-July. There may be 2-3 generations per year with adults entering hibernation in October or November. Appreciable numbers of plant bugs are not seen on snap beans until mid-July.

Host Range

Tarnished plant bugs affect a wide host range including over 50 economic plants, as well as many weeds and grasses. They are often found on alfalfa, tobacco, beans, cucumber, celery, beet, chard, cabbage, cauliflower, turnip, potatoes, strawberries and other small fruit, tree fruit, and many flowering plants.

Environmental Conditions

Weedy fields or fields with a high degree of plant residue may increase the numbers of tarnished plant bugs.

Damage/Symptoms

The tarnished plant bug causes injury to snap beans by inserting their piercing-sucking mouthparts into the plant and removing sap. In addition to the direct damage caused by feeding, the insect also injects a salivary secretion which is toxic to the plant. This toxin will cause blossoms and pods up to 2 inches long to fall off (bud blasting), and pod set will be prolonged, resulting in reduced yields. Feeding on older pods will result in the formation of pits on pods.

Scouting Procedure/ET

Tarnished plant bugs are most accurately sampled with an insect sweep net: take 25 sweeps/sample site with at least 10 sites/100 acres scattered throughout the field. Although no economic thresholds have been determined for this pest on snap beans one/ sweep is a good indication that population levels are high and treatment should be applied, particularly during flowering and pod set.

Integrated Control

Non-Chemical Control

Natural Control: A few insect predators do attack the tarnished plant bug, including a predaceous stink bug, an assassin bug, the big-eyed bug and a damsel bug. However, the amount of control provided by the predators is considered minimal.

Cultural Control: Because the tarnished plant bug overwinters in weeds, often those standing semi-erect during the winter, removal of weeds may help reduce its numbers.

Biological Control: None.

Chemical Control

Commercial: Several insecticides are registered for control of plant bugs. Phorate may be applied in a band over the row at planting but seed contact should be avoided. Disulfoton granules should also be applied during planting. Esfenvalerate, acephate or methomyl should be applied once threshold levels of plant bugs have been reached. Finally, dimethoate and methyl parathion also provide control once an outbreak has occurred however, these materials should not be used during bloom because injury to pollinating bees may result. Refer to the product label for specific application recommendations and precautions.

Homeowner: Sevin applied when populations reach 2 adults or nymphs/plant will provide adequate control.

Insecticide Resistance: None.

References

R.H. Davidson & W.F. Lyon (1979) Insect Pests of Farm, Garden, and Home. 7th Ed. John Wiley & Sons, New York 596 pp.

C.L. Metcalf & R.L. Metcalf (1993) Destructive and Useful Insects, Their Habits and Control 5th Ed. McGraw-Hill Book Co., New York.

White Grub

Scientific Name: *Phyllophaga spp.*
Order: Coleoptera
Family: Scarabidae

General Information

Biological Description

Grubs are white-bodied, 1/2-1 1/2 inches, sluggish, C-shaped larvae with brown heads and six prominent brown legs. The hind part of the body is smooth with body contents showing through skin. True white grubs are distinguished from similar larvae by 2 rows of minute hairs on the underside of the last segment. Adults are the common brown to black May or June beetles seen in the spring. There are several species of white grub in Wisconsin; they typically have three year life cycles. Their activity is primarily nocturnal.

Economic Importance

White grubs are an uncommon seed or seedling pest of snapbeans.

Life Cycle

Most species have a three year life cycle in Wisconsin. Adults emerge and mate in late May to early June. Females search out grassy areas, burrow into the soil and deposit eggs. Eggs hatch in 2-3 weeks and grubs begin feeding on roots and underground plant parts. With the onset of cold weather, the grubs move beneath the frost line in the soil to overwinter. In late May, to early June the grubs migrate back to the surface soil horizons. It is during the second year that the most damage is done as larvae increase in size before they return to the subsoil layers to overwinter. In the third spring, the grubs return to the surface, feed for a short time, and pupate. In late summer, adults emerge from the pupae but remain underground until the following spring. Peak adult flights occur in Wisconsin Every three years and historically have been noted in 1980, 1983, 1986, 1989, 1992 and 1995. The years following peak adult flight characteristically are peak larval damage years (1981, 1984, 1987, 1990, 1993 and 1996).

Host Range

Many species of crops are attacked. All vegetables, strawberries, roses, nursery stock, and most grass and grain crops are susceptible to grub damage.

Environmental Factors

White grub injury is typically a problem in areas which were previously in sod.

Damage/Symptoms

In beans, the grubs feed on roots. This results in a stunting of the plant. Damage is most severe in years following peak adult flights and is most pronounced in crops following sod or fields with grassy weeds.

Scouting Procedure/ET

No thresholds have been established. Grub populations in sod are estimated by turning sod over before September 15, and counting number of grubs/square yard. Populations above 3-4 grubs/square yard are considered damaging.

Integrated Control

Non-Chemical Control

Natural Control: A parasitic fly - Pyrogota spp. parasitizes the grubs and may reduce populations. Birds are effective predators in freshly plowed fields.

Cultural Control: The first year after sod or grassy, weedy alfalfa will be the most damaging. Keeping grass weeds down in spring will prevent egg laying. Use rotation to avoid planting snapbeans into infested fields following years of peak flights. Pasturing hogs on grub infested land will reduce the infestation.

Biological Control: Commercial preparations of milky spore disease are rarely effective.

Chemical Control

Commercial: Because white grubs are not a serious problem in snapbeans, chemical control is not generally recommended.

Homeowner: Apply diazinon (Spectracide) as a broadcast, preplant application and work into the top 6 inches of infested soil.

Insecticide Resistance: None.

References:

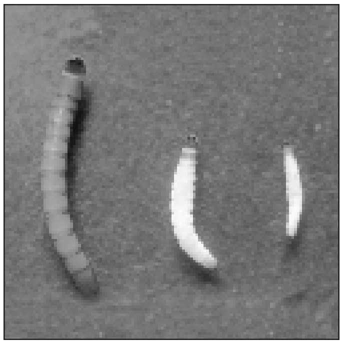
R.H. Davidson and W.F. Lyon (1979) Insect Pests 7th Ed. of Farm, Garden, and Home. John Wiley & Sons, New York. 596 pp.

C.L. Metcalf & R.L. Metcalf (1993) Destructive and Useful Insects, Their Habits and Control. 5th Ed. McGraw-Hill Book Co., New York.

Wireworm

Scientific Name: Many species and genera
Order: Coleoptera
Family: Elateridae

General Information



Biological Description

The larvae of click beetles or wireworms are the damaging stage of this insect. Larvae are thin, yellow to reddish-brown, shiny, jointed, worm-like larvae, 1/4 to 1 1/2 inch in length by 1/8 inch wide. They are distinguished by the ornamentation on the last segment. Adults are hard shelled, brown or black "streamlined" beetles which flip into the air with an audible click.

Economic Importance

Occasional pest of snap beans particularly after sod.

Life Cycle

Wireworms have an extended life cycle, taking from 1-6 years. In Wisconsin, wireworms overwinter as either adults or larvae. Larvae live in the upper six inches of soil and feed on seeds and roots. They migrate only short distances. They are sensitive to moisture and may burrow deeply into the soil in dry conditions. Adults become active in the spring as they fly about searching for a site on which to oviposit. Adult females may live 10-12 months, spending most of this time in the soil where they may lay up to 100 eggs. Eggs are laid in soil in grassy areas. This includes pastures, alfalfa, sod, and grassy weed infestations in row crops. Egg hatch occurs in several days to weeks. Tiny larvae immediately begin to feed on the roots of grasses , weeds and other crops. Because of the extended life cycle, larvae of some species will feed for two to three years before pupating. Adults that emerge from these pupae remain in the pupal chambers until the following spring.

Host Range

Wireworms feed primarily on grasses, including corn and small grains as well as nearly all wild and cultivated grasses. Favored row crops include beans, beets, cabbage, carrots, lettuce, onions, peas, potatoes, and radish. Asters, phlox, gladioli, and dahlias are some of the more commonly infested herbaceous ornamentals.

Environmental Conditions

Wireworms tend to be most damaging 1-4 years after plowing up sod or in poorly drained lowlands, but they are not exclusive to those areas.

Damage/Symptoms

In snap beans wireworm larvae feed on the seed, hypocotyl, or developing cotyledon, causing reduced germination, snakeheads wilted or stunted plants, and "dead" spots scattered in the fields. If the seeds are dug up, they will be riddled with holes and the larvae may be found feeding on the roots of wilted plants.

Scouting Procedure/ET

Scheduled scouting is not recommended and no thresholds have been developed. If wireworm damage is suspected, dig up several ungerminated seeds or damaged plants along with 4-6 inch core of surrounding soil and check for wireworms in and around roots, or in underground portion of the stems. Larvae may be extracted from soil by washing or application of heat to soil surface in funnels.

Integrated Control

Non-Chemical Control

Natural Control: Several natural enemies have been described but they are not effective in reducing populations.

Cultural Control: Crop rotations which avoid susceptible crops and clean cultivation may reduce wireworm numbers. Some species thrive in poorly drained soil and can be reduced by adequate drainage. Clean summer fallowing of infested fields has been effective in some areas. Certain soil types (e.g. silt loams) are particularly susceptible.

Chemical Control

Commercial: Insecticides registered for the control of wireworms in snap beans include diazinon and fonofos but since wireworm damage to snapbeans is rare, treatments are rarely recommended. Both should be soil applied and incorporated prior to planting as a broadcast treatment. Refer to the product label for more information on specific application instructions and precautions.

Homeowner: Apply diazinon as broadcast, preplant application and work into top 6 inches of infested soil.

Insecticide Resistance: None.

References

R. H. Davidson and W. F. Lyon (1979) Insect Pests of Farm, Garden, and Home. 7th Ed. John Wiley & Sons, New York 596 pp.

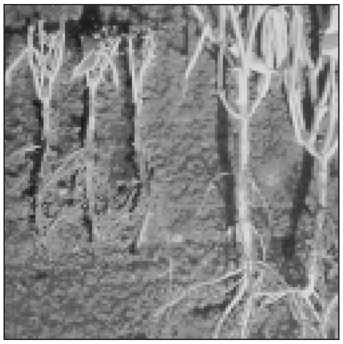
C. L. Metcalf and R. L. Metcalf (1993) Destructive and Useful Insects, their Habits and Control 5th Ed. McGraw-Hill Book Co., New York.

Disease Profiles

Aphanomyces Root Rot

Cause: *Aphanomyces euteiches f sp. phaseoli*

Type: Fungus



General Information

Biological Description

Aphanomyces is one of many fungi that cause root rot and damping-off of seedlings. Along with Pythium, it causes the Common Root Rot Complex in beans. Aphanomyces euteiches f. sp. phaseoli is similar to the Aphanomyces spp. responsible for infection in peas. The fungus belongs to the group known as water molds and produces both sexual oospores and asexual zoospores.

Economic Importance

Aphanomyces euteiches is an important pathogen of beans and peas in Wisconsin. A bean strain of this fungus has recently been found which causes severe root rot of bean. The fungus attacks young seedlings of bean through maturity, but does not cause pre-emergence damping-off symptoms. Pea isolates of this fungus will also attack bean, but do not cause as much damage as the bean isolate.

Disease Cycle

Oospores may persist for many years in the soil. Under warm weather conditions and high soil moisture, infection occurs. Oospores are responsible for the initial infection while zoospores produced in diseased tissue are responsible for secondary infection.

Host Range

Limited host range studies show alfalfa and dry beans to be susceptible. Occasionally radish, beet and cabbage are affected. Soybean, oats and tomato do not appear to be infected.

Environmental Factors

Aphanomyces can survive for long periods in soil. Resting spores germinate and infect plants when environmental conditions are favorable. Aphanomyces zoospores need water to move to new infection sites which indicates why this disease may be more of a problem on irrigated soils. Warm weather (68-82^{o}F) favors disease development.

Symptoms

Post-emergence damping off and necrotic streaking of the hypocotyl are typical symptoms of Aphanomyces root rot. Root lesions begin as yellow-brown lesions which soon coalesce. Typically, hypocotyl streaking extends up the stem into the green tissue giving a grayish, water-soaked appearance or a slight, darkish discoloration up the stem. Aphanomyces and Pythium species often occur together causing a similar stem streak which may cause severe damage to beans. Temperatures above 75^{o}F are needed for severe damage. Stems may be soft and discolored or soft and white, or may be flattened and collapsed from the soil line upward.

Scouting Procedure/ET

Prior to planting beans, a soil sample should be collected and submitted for testing to determine the level of inoculum present. Soil sampling should be done in the fall prior to planting. One gallon of soil should be obtained from multiple sites over a “W” pattern through the entire field. A sampling depth of 6 inches is recommended. Samples should be submitted to the UW-Madison Department of Plant Pathology to determine the disease index. Disease indices which range between 0-50 are safe for planting beans. Indices falling within 51-69 are considered questionable. Fields which rate in the questionable range should not be planted to beans whenever possible. Fields with indices greater than 70 should not be planted to snap beans for several years and should be retested before planting is considered.

Integrated Control

Non-Chemical Control

Cultural: Experiments on peas conducted at the Hancock Agricultural Research Station located in the central sands of Wisconsin, indicate that excessive water may contribute to greater disease severity. Severe losses may occur unless beans are rotated with other crops which are not susceptible to the disease. This will prevent the rapid build-up of populations of Aphanomyces euteiches in the soil. Soil tests should be obtained from fields the fall prior to planting to determine the root rot potential.

Resistant Varieties: Research continues on the development of disease-tolerant breeding lines. Resistant varieties should be available in the near future, however, currently no resistant varieties exist.

Chemical Control

Seed treatment with Captan fungicide may be effective in reducing infection. Once infection has occurred, chemical fungicide treatments currently available fungicides are ineffective. Soil fumigation helps to reduce soil borne inoculum.

Fungicide Resistance: None

References

Compendium of Bean Diseases. 1991. The American Phytopathological Society. St. Paul, MN. 73pp.

Zaumeyer, W. J. and H. R. Thomas. 1957. A monographic study of bean diseases and

Bacterial Brown Spot

Cause: *Pseudomonas syringae* pv. *syringae*

Type: Bacterium

General Information

Biological Description

Bacterial brown spot is caused by *Pseudomonas syringae* pv. *syringae*, a rod-shaped, gram-negative bacterium. The bacterium is motile and aerobic. Colonies grown in culture on nutrient media are fluorescent.

Economic Importance

Bacterial brown spot rarely kills the affected plant. In severe infections, all foliage may be destroyed and yields lowered. Several cultural practices along with the use of fixed copper bactericide applications help control this disease.

Disease Cycle

The bacterium overwinters on weeds such as hairy vetch and other perennials which remain green throughout the winter. It is doubtful if the bacterium can overwinter in diseased bean refuse buried in the soil. In moist weather, diseased plant leaves may be covered with bacterial exudate, which is splashed by rain or irrigation water. It may also be carried by insects, tools, and clothing to other plants or fields. The organism enters the plant through natural openings such as the leaf stomata. New lesions resulting from infection appear in 3-5 days. Optimum temperatures for disease development occur between 60-90^{o}F.

Host Range

The brown spot bacterium affects a wide range of plants. Among these are snap bean, wax bean, lima bean, cowpea, broad bean, most other beans, hairy vetch, Prunus spp. (peach, plum, cherry family), pea, lilac, clover, Sudan grass, sweet corn, sweet sorghum, poplar, forsythia, buckwheat, rose and many other plants.

Environmental Factors

Optimum temperatures for disease development occur between 60-90^{o}F. The disease is most severe and most difficult to control during years when there is excessive rainfall, long periods of leaf wetness, and wind/hail damage to the foliage.

Symptoms

Brown spot first appears on leaves as water-soaked spots that remain very small and become reddish-brown in color. These spots are irregularly circular and are somewhat sunken. As the dead cells dry, the center of the spot turns gray and may crack open or fall away, leaving a “shot hole”. On the lower leaf surface, the veins turn red or reddish brown. In the most severe infections, the foliage is killed. More elongated spots than those on the leaves are produced on stems. Stem lesions are sunken and pod lesions are often surrounded by pale brown halos, about 1/2 inch in diameter. Pod infection may lead to distorted or malformed pods. Seeds produced on infected plants are often shriveled and discolored.

Scouting Procedures/ET

There are no formal monitoring procedures recommended for bacterial brown spot. Examination of plants for early symptoms should be made during routine insect monitoring visits.

Integrated Control

Non-Chemical Control

Cultural: Plant disease-free seeds produced under certification in western states. Control weed hosts of the pathogen such as hairy vetch in, and around, bean plantings. Incorporate bean refuse by plowing immediately after harvest.

Resistant Varieties: Resistant cultivars include Benton, Bush Bean Florence, Hy Style, and Tenderlake. Additional cultivars with brown spot resistance are under development.

Chemical Control

Seed treatments of streptomycin sulfate will help inactivate the bacteria which is present on the seed surface. Seed is not routinely treated although this practice may be done where disease is a concern. Copper ammonium complex, copper salts of fatty or rosin acids and copper hydroxide may slow the spread of the disease once infection has begun. Often synchronization of spray application with severe thunderstorms will prevent outbreaks or at least help to minimize infection.

Fungicide Resistance: None

References

Compendium of Bean Diseases. 1991. American Phytopathological Society Press. St. Paul, MN. 73pp.

Sherf, A. F. & A. A. MacNab. 1986. Vegetable Diseases and Their Control. John Wiley & Sons, Inc. New York. 728pp.

Zaumeyer, W. J. and H. R. Thomas. 1957. A monographic study of bean diseases and methods for their control. USDA Tech. Bull. No. 868. 255 pp.

Baldhead

Scientific Name: None

Type: Abiotic

Common Name: Snakehead

General Information

Biological Description

Baldhead or snakehead are names given to describe distorted seedlings which develop as a result of mechanical injury to bean seed during threshing and further handling. The seeds may be injured externally with injury or damage to the seedcoat or cotyledons or internally with injury to the rudimentary stem or root cells. Baldhead may also result from internal damage due to bacterial pathogens.

Economic Importance

Baldhead is widespread and common in occurrence. Rarely does the number of affected plants reduce yield. Depending on the bean variety, moisture content of the seed, and threshing speeds, damage to seedlings can range from 0-80%. However, of the various types of baldhead seedlings, only those involving the loss of both primary leaves are sufficient to cause yield loss in the subsequent crop.

Disease Cycle

None.

Host Range

All types of beans are susceptible to seed injury and the resulting baldhead symptoms.

Environmental Factors

If injured seed is planted, even ideal environmental conditions can result in abnormal plants.

Symptoms

The external seed symptoms of baldhead are characterized by cracks of various sizes in the seed coat and cotyledons. The extent of cracking varies from almost invisible fissures to bad mutilation of seed. Internally injured seeds are usually the ones which produce baldhead or snakehead plants. Some plants fail to emerge while others with injured stem parts emerge, but have no growing tip. Seedlings may die or develop buds at the cotyledonary nodes that result in late, distorted, and stunted growth. Mutilation of root parts within the seed is also common. This may cause numerous adventitious roots to develop which help to keep the plant alive. The development of the plant is delayed and such plants fail to produce pods until late in the season. In examining the field symptoms, growers should be alert for evidence of insect feeding injury since larvae of the seed corn maggot can also cause symptoms resembling baldhead.

Scouting Procedure/ET

There are no formal monitoring procedures recommended for baldhead. While scouting the field for other diseases and insects, note what percentage of plants are abnormal.

Integrated Control

Non-Chemical Control

Cultural: High moisture content in beans reduces threshing damage; whereas, dry beans are easily damaged. The moisture content of the seed should not be allowed to fall below 15%. Equipment used for cleaning, milling and polishing the seed after it is threshed should be designed and operated to prevent seed impacts that cause injury. Much seed injury is a result of additional impacts caused by each handling process.

Resistant Varieties: All bean varieties are liable to seed injury, but there is much variation in the extent or type of injury between varieties. Baldhead in lima beans can range from 2-16% incidence.

Chemical Control

There is no chemical control for this abiotic disorder.

Fungicide Resistance: None.

References

Compendium of Bean Diseases. 1991. American Phytopathological Society Press. St. Paul, MN. 73pp.

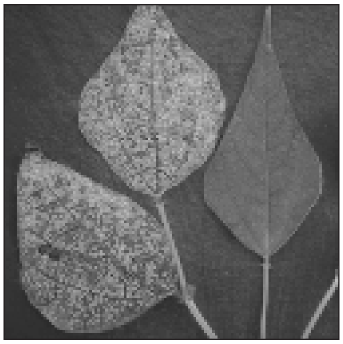
Sherf, A. F. & A. A. MacNab. 1986. Vegetable Diseases and Their Control. John Wiley & Sons, Inc. New York. 728pp.

Zaumeyer, W. J. and H. R. Thomas. 1957. A monographic study of bean diseases and methods for their control. USDA Tech. Bull. No. 868. 255 pp.

Bean Yellow Mosaic Virus

Scientific Name: Bean Yellow Mosaic Virus

Type: Virus



General Information

Biological Description

The virus which causes Bean Yellow Mosaic is a potyvirus which belongs to the group of viruses which are similar to the potato Y virus and are comprised of a single strand of RNA.

Economic Importance

Bean yellow mosaic is a very common and widespread disease of bean. It is transmitted by aphids from plant to plant and can cause considerable losses. Infected plants are stunted and produce few or no pods. Pods that are produced may be distorted. In severe cases when up to 100% of a field is infected, pod yield may be reduced by as much as 33% while beans grown for seed may realize yield reductions of up to 40%.

Disease Cycle

BYMV is not transmitted in bean through seed. The primary vectors for this disease are aphids. pea aphid *(Acyrthosiphon pisum)*, green peach aphid (*Myzus persicae*), potato aphid *(Macrosiphum euphorbia)* , and the black bean aphid *(Aphis fabae)* are the primary species responsible for disease dissemination. The virus overwinters in perennial leguminous weeds and is transmitted to bean in the spring when the aphids become active.

Host Range

The following plants are susceptible to bean yellow mosaic virus: snap bean, broad bean, lima bean, chickpea, sweet pea, green pea, white sweet clover, soybean, crimson clover, red clover, white clover, vetch, alfalfa, gladiolus, poppy, tobacco, white lupine, lambsquarters, and Canada thistle. In all, seventy-seven legumes and three non-legumes are natural hosts for this virus.

Environmental Factors

Mild winters and hot, dry periods in spring and summer seasons favor the development of high aphid populations. The incidence of this disease is greatest when large numbers of aphids are present in field situations. Disease usually spreads inward from field edges as aphids migrate.

Symptoms

The symptoms of BYMV resemble those of common mosaic. One week after inoculation, symptom expression begins. Leaf mottling with extensive areas of yellow and light green is usually the most conspicuous symptom. This helps distinguish this disease from common mosaic. The yellow areas enlarge until the whole plant takes on a yellowish cast. The leaflets curl downward at the margins and droop at the point where they are attached to the petiole. Leaflets of infected plants are more brittle than normal. On some varieties there is a distinct stunting and almost complete absence of pods or a much delayed maturity. In some instances, the leaflets remain small, become puckered, and the few pods that develop are marred by distortion, have reddish-brown blotches on the surface, and show internal darkening.

Scouting Procedure/ET

A rigorous scouting program which includes monitoring aphid populations is useful in determining when aphid populations have reached injurious levels. It is also beneficial to monitor aphid populations in nearby fields, especially small grains and alfalfa and in weed borders which surround bean fields.

Integrated Control

Non-Chemical Control

Cultural: Virus diseases are difficult to control. The incidence of bean yellow mosaic can be reduced by controlling aphids with insecticides and by not planting beans near perennial hosts of this virus, such as clover or alfalfa fields. The most important sources of infection seem to be crimson and red clover, alfalfa and the gladiolus. Therefore, beans should not be planted near to these crops and especially not close to old clover sods. It is advisable to rogue out the first infected plants as soon as they are observed, but if the number of infections increases rapidly, rouging becomes impractical.

Resistant Varieties: Although planting resistant varieties would effectively reduce the incidence of infection, few such snapbean varieties are available. Blue Lake Bush 274, Goldrush, Magnum, Opus, Provider, Romano Bush, Slenderette, Tema, Tendercrop, Tess, Topcrop, and Wrangler are resistant to BYMV. Resistant wax bean varieties include Cherokee Wax, Goldcrop, and Sungold.

Chemical Control

Control aphid populations early. Consult UWEX Publication A3422, Commercial Vegetable Production in Wisconsin for specific insecticides registered for aphid control in snapbeans. There are no fungicidal controls once the plants become infected.

Fungicide Resistance: None.

References

Compendium of Bean Diseases. 1991. American Phytopathological Society Press. St. Paul, MN. 73pp.

Sherf, A. F. & A. A. MacNab. 1986. Vegetable Diseases and Their Control. John Wiley & Sons, Inc. New York. 728pp.

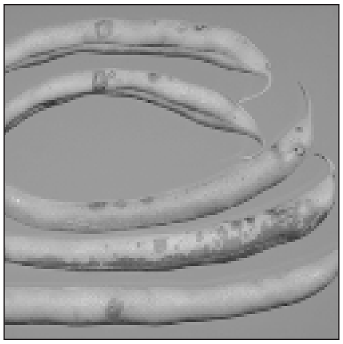
Zaumeyer, W. J. and H. R. Thomas. 1957. A monographic study of bean diseases and methods for their control. USDA Tech. Bull. No. 868. 255 pp.

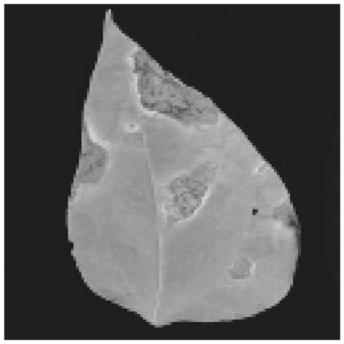
Common Blight

Scientific Name: *Xanthomonas campestris* pv. *phaseoli*

Type: Bacteria

Common Name: Bacterial Blight





General Information

Biological Description

The bacterium responsible for common blight is an aerobic, gram-negative rod. The bacteria move by means of a flagellum. The organism may be isolated relatively easily on selective media. flagellum. The organism may be isolated relatively easily on selective media.

Economic Importance

Common blight has the potential to be an important pathogen throughout the United States wherever rain favors the dissemination of the pathogen. Planting of clean seed, however, generally provides adequate control in most areas. Once introduced on seed, the severity of the disease varies depending on weather conditions. Losses may range from a trace up to 60% in beans. The bacteria are seed transmitted and infected seed produces diseased plants.

Disease Cycle

The bacteria overwinter in diseased vines and in the seed. Seedborne infections begin with the contamination of the cotyledons as the seed germinates. The infection then spreads to the leaves. The bacteria may enter the foliage directly through the stomates and wounds or they may be translocated upward in the plant through the xylem from sites of root infection. Usually, the bacteria are spread from infected seedlings by wind, rain, dust, tools, equipment, animals and humans.

Host Range

In addition to snap bean, common blight infects lima beans, as well as other bean species.

Environmental Factors

The blight develops rapidly under favorable conditions of relatively high air temperatures (75-90 degrees F) and high humidity or free moisture.

Symptoms

Lesions first appear on leaves as small, water-soaked or light green areas. As the spots develop, the center becomes dry and brown and are bordered by a narrow chlorotic zone. On more susceptible varieties, the spots continue to enlarge until lesions cover much of the leaf surface or combine with other lesions to kill the leaflet. Winds and rain tear the affected foliage. Similar lesions form on the pods and often coalesce into broad, irregular blotches. During periods when moisture is prevalent, a yellowish crust, comprised of bacterial cells, covers the surface of the lesion. Pod infection appears as water-soaked spots on beans. Usually, the seeds within do not develop and are shriveled. Infected seeds produce seedlings with symptoms characteristic of the disease. Water-soaked cankers may form at nodes so that young plants are weakened and often break at the nodes. The entire plant is seldom killed unless the stem is girdled.

Scouting Procedure/ET

Monitor fields weekly to determine the level of infection. Sample 5-10 sites per field following a 'W' pattern across the field.

Integrated Control

Non-Chemical Control

Cultural: Crop rotation of about 3 years is essential to reduce the amount of soil inoculum. Use disease-free seed. Early planting may reduce the incidence of disease. Rouging infected plants is of limited value in controlling this disease. Good sanitation practices will also prevent the spread of common blight into non-infected fields.

Resistant Varieties: There are few sources of resistance to common blight of snap bean which show any resistance to common blight. However, many sources exhibit a tolerance to the disease. Dry bean varieties which exhibit some resistance include Great Norther Tara, Jules and Valley.

Chemical Control

Commercial: Streptomycin seed treatment at a rate of 3% will help inactivate the bacteria which may be present on the seed surface. Foliar applications of copper hydroxide, copper ammonium complex or copper salts of fatty or rosin acids provide some controls in light infestations.

Homeowner: Practice crop rotation, fall plowing under of debris and planting disease-free seed to prevent infection.

Fungicide Resistance: None

References

Compendium of Bean Diseases. 1991. American Phytopathological Society Press. St. Paul, MN. 73pp.

Hagedorn, D. J. and D. A. Inglis. Handbook of Bean Diseases. A3374. UW-Extension Publication, Wisconsin. 1986. 24 pp.

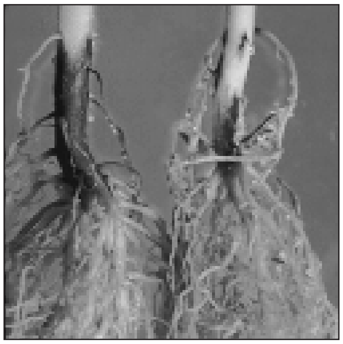
Sherf, A. F. & A. A. MacNab. 1986. Vegetable Diseases and Their Control. John Wiley & Sons, Inc. New York. 728pp.

Fusarium Root Rot

Scientific Name: *Fusarium solani* f.sp. *phaseoli*

Type: Fungus

Common Name: Dry Root Rot



General Information

Biological Description

The causal organism is an imperfect fungus which produces both macro- and micro-conidia and thick-walled, resting chlamydospores. When grown on media, the fungus is slow to develop

Economic Importance

Fusarium root rot can be severe in fields where beans have been in continuous cultivation especially when the soil is too wet, too cold or too hot for good plant growth. This disease chiefly occurs during mid- or late season.

Disease Cycle

The fungus overwinters as chlamydospores in infected bean debris. Fusarium spores are disseminated by machinery, animals, humans and splashing water. Chlamydospore germination in the spring results as a response to exudates produced by germinating beans. The fungus enters the roots and infects the xylem and cortical tissues. The fungus can remain alive in the soil for many years.

Host Range

In addition to snap bean, other plants are known to be susceptible to the fungus. These include cowpea, lima bean, garden pea, and dry bean.

Environmental Factors

Any soil or climatic condition that makes the bean plant grow more luxuriantly reduces the losses from root rot. The disease causes more damage when temperatures are around 72 degrees F than at 90 degrees F, because the bean plant grows better at the higher temperature. The disease is more severe if conditions are unusually dry while little injury is caused if plants can obtain adequate moisture. High populations of the nematode *Pratylenchus penetrans* and *Meloidogyne* may enhance infection.

Symptoms

A slight reddish discoloration of the taproot appears a week or more after the seedling emerges. This discoloration gradually becomes brick-red as the diseased area enlarges to cover most of the taproot. The diseased area may have no definite margin, or it may occur in streaks that may extend nearly to the surface of the soil, but rarely above it. The taproot later turns brown and length-wise cracks generally develop. The small lateral roots and the end of the taproot usually shrivel and die. Affected plants are somewhat stunted and grow more slowly than healthy plants. Later, a cluster of fibrous roots may form just under the soil surface and above the stem decay. These roots frequently drop prematurely, and pods are few and poorly filled. In severe attacks, many plants may be killed. However, if soil moisture is adequate, a somewhat normal crop may be produced.

Scouting Procedure/ET

Monitor fields weekly throughout the growing season. Follow a 'W' pattern through the field and dig samples to examine roots for symptoms of disease.

Integrated Control

Non-Chemical Control

Cultural: The best means to control this root rot is to use long rotations and various other cultural practices. Plant beans early on well-drained, well-fertilized soil that is likely to give excellent growth of plants. A 6-8 year rotation including wheat should be practiced to hold the disease in check and to insure that a profitable crop can be grown. A 2-3 year rotation is of little value once the disease has become a problem. Bean refuse should be plowed under immediately after harvest so it will be decomposed quickly. During the season, shallow cultivation should be practiced to avoid root pruning injury. Cultivation should cease as soon as root rot appears unless the soil is packed hard so that roots have difficulty growing. Irrigation helps infected plants to tolerate the disease during dry periods.

Resistant Varieties: Resistance to fusarium in bean appears to be linked with undesirable plant characteristics. As a result, few resistant snapbean varieties are available.

Chemical Control

None.

Fungicide Resistance: None.

References

Compendium of Bean Diseases. 1991. American Phytopathological Society Press. St. Paul, MN. 73pp.

Hagedorn, D. J. and D. A. Inglis. Handbook of Bean Diseases. A3374. UW-Extension Publication, Wisconsin. 1986. 24 pp.

Sherf, A. F. & A. A. MacNab. 1986. Vegetable Diseases and Their Control. John Wiley & Sons, Inc. New York. 728pp.

Halo Blight

Scientific Name: *Pseudomonas syringae* pv.*phaseolicola*

Type: Bacterium

General Information

Biological Description

Several races of *Pseudomonas syringae* pv. *phaseolicola* are known. The bacteria is a gram-negative rod and when cultured in a laboratory, it produces a green fluorescence.

Economic Importance

Halo blight is one of three bacterial blights which affect beans. Symptoms of halo blight are similar to common blight, and it is often difficult to distinguish these diseases based on symptoms alone. Halo blight is usually less important than common blight in the United States because many dry-type beans are resistant to halo blight. However, the diseases may become epidemic in different regions at different times of the season since halo blight is favored by cool weather, while common blight is favored by warm weather. Halo blight is transmitted through bean seed and can cause serious losses in fields where diseased seeds are planted.

Disease Cycle

The bacteria responsible for halo blight overwinters in diseased vines and in the seed. Because the bacterium is so infectious, only one infected seed in several thousand is sufficient to cause a severe infection. Usually, the bacteria are spread from infected seedlings by wind, rain, dust, tools, equipment, animals, and humans. The bacterium enters the leaves through the stomata or wounds. Pod infection can occur either directly from splashing water carrying the bacteria or it may travel via the plant's vascular system from other plant parts. Halo blight develops rapidly when the weather is cool and humid.

Host Range

Halo blight affects snap bean, wax bean, scarlet runner bean, tepary bean, soybean and lima bean.

Environmental Factors

Halo blight develops rapidly when the weather is cool and humid. The typical lesions of the disease are produced at temperatures of 60-68^{o}F.

Symptoms

The first symptoms on seedlings are small, angular, water-soaked spots 1/8 to 1/4 inch in diameter on the lower leaf surface. As the disease progresses, these lesions enlarge and coalesce. later, a halo-like cone of greenish-yellow tissue approximately 1 inch in diameter develops outside the water-soaked area. This halo symptom helps to distinguish halo blight from another bacterial disease, common blight. The halo effect tends to disappear when the air temperature is above 70-75^{o}F. Under warmer conditions, the spots become angular and reddish-brown to brown in color. In the early stages of development, plants in a bean field infected with halo blight can also be distinguished from those infected with common blight by the characteristic yellow color of the leaves. Infected leaves may also be malformed, crinkled, and mottled. Infected leaves or even entire plants may wilt and die quickly. It is important to be able to recognize the variability of the symptoms to determine the duration of the infection and the potential extent of crop loss.

Stems, pods, and seed may also be infected. Pod lesions appear similar to those on leaves, but a cream or silver-colored bacterial exudate may develop from the lesion. Infected seeds may rot or shrivel, or they may be discolored. They are often smaller than normal.

Scouting Procedure/ET

Once symptom expression has begun, it is too late to stop the spread of the disease within the field. As a result, monitoring for disease is of little benefit. If halo blight is observed in a field, this field should be scouted last in the day. Boots and clothing making contact with infected plants should be thoroughly sanitized before resuming scouting since the pathogen is easily spread from plant to plant.

Integrated Control

Non-Chemical Control

Cultural: Plant only certified, disease-free seed grown in blight-free regions. In regions of states such as California and Idaho, the humidity is normally too low for the causal bacteria to infect the plant. A three year rotation which excludes beans, soybeans and cowpeas will reduce inoculum buildup. Do not cultivate or handle plants which are wet with dew or rain ,as this may spread the bacteria from plant to plant. Plow under all plant debris immediately after harvest.

Resistant Varieties: Some plant varieties possess only resistance to leaf infection and pod infection is not lessened. The snap bean varieties Acclaim, Applause, Crest, Dorabel, Espada, Gold Mine, and Narbone are reported to be tolerant of halo blight.

Chemical Control

In areas where halo blight has been a problem, seed treatment with streptomycin sulfate to inactivate bacteria on the seed surface may be of benefit. Copper ammonium complex, copper salts of fatty or rosin acids, and copper hydroxide may slow the spread of the disease.

Fungicide Resistance: None.

References

Compendium of Bean Diseases. 1991. American Phytopathological Society Press. St. Paul, MN. 73pp.

Sherf, A. F. & A. A. MacNab. 1986. Vegetable Diseases and Their Control. John Wiley & Sons, Inc. New York. 728pp.

Zaumeyer, W. J. and H. R. Thomas. 1957. A monographic study of bean diseases and methods for their control. USDA Tech. Bull. No. 868. 255 pp.

Hopperburn

Cause: Leafhopper Feeding

Type: Insect

General Information

Biological Description

The leafhopper responsible for the disorder is the potato leafhopper (*Empoasca fabae*), a wedge-shaped, pale green, insect about 3 mm long with whitish spots on its head. It is a very active insect, flying, jumping or running backwards or sideways rapidly when disturbed. The injury is produced by the mechanical effects of leafhopper feeding and by the injection of a toxin into the plant. Hopperburn appears soon after feeding begins. This disorder can cause serious damage to potatoes in certain seasons.

Economic Importance

Hopperburn of potatoes occurs widely in the United States.

Disease Cycle

Please refer to the plant pest profile on the potato leafhopper for more information on this insect's life cycle.

Host Range

Potato leafhoppers prefer to feed on alfalfa, apples, all types of beans, celery, eggplant, potato, and nursery stock as well as other cultivated crops and weeds.

Environmental Factors

Hopperburn develops most rapidly during hot, dry weather.

Symptoms

Both nymphs and adults feed by inserting their piercing/sucking mouthparts into the vascular tissue of the plant and extracting sap. Damage is caused to both xylem and phloem tissues. Indirect damage results from the introduction of a toxin with the saliva during feeding. General symptoms include stunted plants with chlorotic foliage that curls upward at the margins. Early symptoms include triangular, brownish spots at the leaflet tip or at the leaf margins near veinlets. Browning progresses inward from the margins and leaf margins become dry and brittle. Often, only a narrow strip of green tissue remains along the midveins. The burned appearance of the foliage is where the term 'hopperburn' is derived. Symptoms of feeding injury begin on older foliage and move upward. Pre-mature death of untreated vines causes severe yield reduction. Damage may be more severe in hot, dry years. Nymphs are more injurious than adults.

Scouting Procedure/ET

Please refer to the plant pest profile on the potato leafhopper for scouting procedures and economic thresholds.

Integrated Control

Non-Chemical Control

Cultural: Follow good cultural practices and keep soil adequately moist. When the leafhopper population is high, it is difficult to produce a good crop unless the insect is controlled by insecticide sprays or dusts.

Resistant Varieties: Varieties of potato are being developed which are resistant to the potato leafhopper toxin.

Chemical Control

Commercial: Please refer to the plant pest profile on the potato leafhopper for more information on the chemical control of this insect.

Fungicide Resistance: None.

References

Sherf, A. F. & A. A. MacNab. 1986. Vegetable Diseases and Their Control. John Wiley & Sons, Inc. New York. 728pp.

Pythium Root Rot

Common Names: Damping-off, Hollow Stem Root Rot

Cause: *Pythium* spp.

Type: Fungus

General Information

Biological Description

Pythium is one of many fungi that cause root rot and damping-off of seedlings. Along with Aphanomyces, it causes the Common Root Rot Complex in beans. It is one of the major causes of poor crop stands. The disease is so universal that many growers overplant to insure a good stand. Several species of Pythium can cause this disease. The fungus attacks plants at any stage of development from an ungerminated seed to a mature plant. Older plants are more tolerant to the fungus, however. Pythium is a member of the group of fungi known as water molds. As the name implies, free water is necessary for disease development.

Economic Importance

The disease is especially common where intensive cropping of beans has occurred. Yield losses may reach 100%.

Disease Cycle

Pythium spp. can live for long periods in the soil. Resting oospores germinate and infect plants when environmental conditions are ideal. An excess of moisture is recognized as the most important condition for the development of damping-off. Motile pythium zoospores which result in secondary infection, require water to move to new infection sites. Soils that hold moisture for long periods favor the development of damping-off. Low spots in fields also favor the disease. Several species of Pythium can cause damping off. Each species varies in its temperature requirements.

Host Range

A number of species of Pythium attack all types of beans, as well as most every vegetable crop.

Environmental Factors

An excess of moisture is recognized as the most important condition for damping-off. Pythium zoospores require water to move to new infection sites. Soils that hold moisture for long periods favor the development of damping-off. Low spots in fields also favor the disease. Disease can be caused by several species of Pythium in warm or cold weather with some more active at 57-61°F while others reach peak activity at 82-86°F.

Symptoms

Seedlings may rot in the soil before and after germination. This is called pre-emergence damping-off. Young plants breaking through the ground may also be attacked by Pythium (post-emergence damping-off). The stem of the plant at or below the soil surface may be infected. The initial point of infection appears as a slightly sunken, water-soaked lesion. The fungus spreads up and down the stem producing a semisoft, reddish to dark-brown rot. The pith of the stem may be destroyed, giving rise to the descriptive name “hollow stem”. Stems are not soft or discolored, but may be flattened or collapsed from the soil line upward for a few inches. These young plants may survive for a short time, but eventually die. Plants which are older when infection occurs are more resistant. When infected, older plants may have brown stem scars near the soil surface. When the weather is hot and humid, a soft, slimy rot of the stem and branches may occur. Infected plants wilt and generally die. Fields with indices greater than 70 should not be planted to snap beans for several years and should be retested before planting is considered.

Scouting Procedure/ET

Prior to planting beans, a soil sample should be collected and submitted for testing to determine the level of inoculum present. Soil sampling should be done in the fall prior to planting. One gallon of soil should be obtained from multiple sites over a “W” pattern through the entire field. A sampling depth of 6 inches is recommended. Samples should be submitted to the UW-Madison Department of Plant Pathology to determine the disease index. Disease indices which range between 0-50 are safe for planting beans. Indices falling within 51-69 are considered questionable. Fields which rate in the questionable range should not be planted to beans whenever possible.

Integrated Control

Non-Chemical Control

Cultural Control: Plant seeds in well-drained soil. Damping off can be held in check fairly well by avoidance of overwatering. Timely irrigation and supplemental nitrogen applied as a sidedress will help induce development of adventitious roots above the area of decay, thus allowing plant survival and acceptable yield production. Conventional tillage may result in a reduced rate of infection as compared with minimum tillage. Subsoiling 20-22 inches can promote deep rooting and improve yields. Green plowdown of cover crop has been implicated in increased inoculum. Follow fertilizer recommendations for optimum plant growth. Excess nitrogen has been shown to contribute to disease losses.

Resistant Varieties: Research continues at UW-Madison and seed companies on development of root rot tolerant breeding lines.

Chemical Control

Chemical seed treatments with captan and metalaxyl may provide some benefit. Soil fumigation helps to reduce soil borne inoculum.

Fungicide Resistance: None.

References

Compendium of Bean Diseases. 1991. American Phytopathological Society Press. St. Paul, MN. 73pp.

Sherf, A. F. & A. A. MacNab. 1986. Vegetable Diseases and Their Control. John Wiley & Sons, Inc. New York. 728pp.

Zaumeyer, W.J. and H.R. Thomas. 1957. A monographic study of bean diseases and methods for their control. USDA Tech. Bull. No.868. 225 pp.

Rhizoctonia Root Rot

Scientific Name: *Rhizoctonia solani*

Type: Fungus

Common Names: Stem Canker, Damping Off

General Information

Biological Description

The fungus which causes this disease may be recognized microscopically by the right-angle branching of its hyphae with a crosswall near the branch. The overwintering sclerotia are black.

Economic Importance

Rhizoctonia is a common and widespread fungus that affects most vegetables. It generally attacks young bean plants that are growing under adverse conditions or plants which have been wounded. Losses from Rhizoctonia root rot vary greatly in different locations and from year to year. Losses of 5-10% are common.

Disease Cycle

Rhizoctonia overwinters as sclerotia in the soil of infested plants. Dissemination occurs via rain or irrigation water, wind or machinery. Infection may occur through wounds, natural openings or intact tissue. The fungus usually attacks plants that are growing under unfavorable environmental conditions. As the food in the decaying tissue becomes exhausted, the mycelium rounds up into dense, brown, kernel-like bodies called sclerotia. These sclerotia resist unfavorable conditions for an indefinite period.

Host Range

A number of strains of *Rhizoctonia solani* are common which attack beans as well as most other vegetables.

Environmental Factors

Rhizoctonia is very common in the soil. Environmental conditions largely determine the amount of loss in the crop. An excess of moisture is recognized as the most important condition favoring infection and disease development.

Symptoms

Rhizoctonia root rot is most severe on 2-3 week old bean plants. Infected seedlings wilt and collapse from a water-soaked rot of the stem near the soil line. Infected plants may also become twisted and stunted. Adjoining plants may later become infected. Sunken stem cankers may develop and are reddish-brown to brick red. These extend longitudinally on the stem and may become somewhat sunken. If the plant is young and succulent, it usually dies soon after infection. If the stem is somewhat woody, the plant shows little indication of being diseased, although the yield is generally reduced. The fungus may enter the pith of lower stems where it causes a brick red discoloration. Resting structures of the fungus called sclerotia, may be found on, or within the stems of dying plants. Affected plants are often stunted with chlorotic foliage.

Scouting Procedure/ET

Monitor fields weekly throughout the growing season. Follow a 'W' pattern through the field and dig samples to examine the roots for symptoms of the disease.

Integrated Control

Non-Chemical Control

Cultural: Rhizoctonia is controlled by using several standard cultural practices. Only disease-free seed should be planted since the fungus is transmitted through seed. Do not overseed. Plant in soils with good drainage. Practice long rotations with unrelated crops. Maintain adequate soil fertility to promote vigorous plant growth.

Resistant Varieties: There are no commercially available resistant varieties.

Chemical Control

None.

Fungicide Resistance: None.

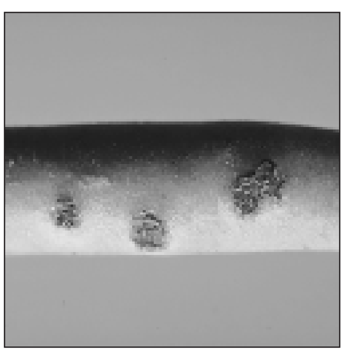
References

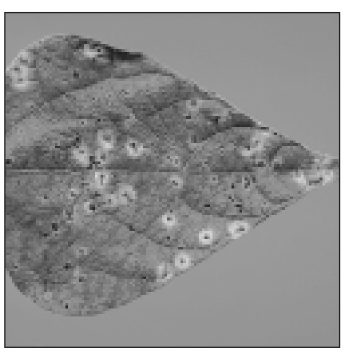
Hagedorn, D. J. and D. A. Inglis. Handbook of Bean Diseases. A3374. UW-Extension Publication, Wisconsin. 1986. 24 pp.

Rust

Scientific Name: *Uromyces appendiculatus*

Type: Fungus





General Information

Biological Description

Uromyces appendiculatus belongs to the basidiomycete group of fungi. Unlike many other rust fungi, bean rust is autoecious, which means it only requires one host for complete development. Only three of the five spore types characteristic of rust fungi are produced by *U. appendiculatus*. rarely are pycnia and aecia found in nature. There are many races within the species.

Economic Importance

Bean rust is a very widespread disease and can be economically important in areas where beans are grown intensively and where the relative humidity is usually high. Losses can be 100% and are most severe when infection occurs early in the season.

Disease Cycle

Unlike most rust fungi, bean rust requires only beans to complete its life cycle. The fungus overwinters as telial spores which represent the primary inoculum in the spring. The disease is disseminated by insects, wind, equipment or humans. Infection occurs through the stomates or wounds.

Host Range

Rust is primarily a problem on snap bean and dry bean. It is found less often on lima bean, scarlet runner, horsebean, cowpea, asparagus-bean, and several other *Phaseolus* species.

Environmental Factors

Depending on the location, the fungus overwinters as one of two types of spores, summer uredial spores or winter telial spores. Cloudy, humid days favor bean rust development as do long foliar wetness periods. Beating rains hinder disease development. Medium to high temperatures are required for heavy infection to occur however, the fungus ceases to develop at temperatures above 93° F. The uredial spores germinate and infect plants most readily between 60-75 degrees F, while the winter spores have an optimum temperature range between 50-60 degrees F. The rust organism is daylength sensitive and uredial spores are produced only when the hours of light exceed those of darkness. As the daylength begins to decrease in late summer, telial spores are produced.

Symptom

The rust pustules appear on any part of the plant above ground. Lesions are numerous on the lower leaf surface and less abundant on the pods. Infection is first evident as tiny, white, raised pustules. As the infection worsens, the lesions become distinct, reddish-brown and circular. As many as 2000 pustules may be found on one leaf. Each pustule contains numerous rust-colored or brown spores. On some varieties of beans, these pustules or sori are surrounded by a yellow halo. Heavily infected leaves shrivel and fall from the plant. In severe infections, many plants in the field may become defoliated.

Scouting Procedure/ET

Scout fields weekly between early bloom and 4 weeks before harvest. If there are 5 or more weeks to harvest the threshold level is 2 or more lesions per leaf. When there are less than 5 weeks until harvest, 40 lesions per leaf should be the threshold.

Integrated Control

Non-Chemical Control

Cultural: Practice long crop rotations to reduce the build-up of bean rust inoculum in fields. Plowing the field to bury bean debris once the field has been harvested will reduce the inoculum. Do not plant beans close to stacks of old bean straw infested with rust. Infested bean straw should not be used for feeding or bedding livestock.

Resistant Varieties: Whenever possible, rust tolerant bean varieties should be grown. There are several races of the fungus which exist and no single bean variety is resistant to all races. Tolerant varieties of snap beans or pole beans include Bounty, Goldkist, Green Lantern, Kentucky Blue, Kentucky Wonder, Labrador, Mustang, Opus, and Tenderlake.

Chemical Control

Chlorothalonil fungicide treatments should begin at the first signs of disease. Treatments should be made every 7 days to protect newly emerging foliage. If infection doesn't appear within 4 weeks of harvest, chemical treatment is unnecessary. Consult UWEX Publication A3422, Commercial Vegetable Production in Wisconsin and the product label for specific application instructions and precautions.

Fungicide Resistance: None.

References

Compendium of Bean Diseases. 1991. American Phytopathological Society Press. St. Paul, MN. 73pp.

Hagedorn, D. J. and D. A. Inglis. Handbook of Bean Diseases. A3374. UW-Extension Publication, Wisconsin. 1986. 24 pp.

Sherf, A. F. & A. A. MacNab. 1986. Vegetable Diseases and Their Control. John Wiley & Sons, Inc. New York. 728pp.

Seedcoat Splitting

Common Name: Seedcoat Rupture

Cause: Uneven Seed Growth

Type: Physiological

General Information

Economic Importance

Seedcoat splitting reduces the quality of dry edible beans and also those produced for seed. Split seeds often rot when planted.

Disease Cycle

Seedcoat splitting appears to be a result of uneven growth of the cotyledon and seedcoat during seed maturation. The highest amount of seed rupture usually occurs in pods from the earliest flowers that develop while the plants are in the most vigorous condition. It has also been observed that when large and small-seeded varieties are crossed, the resulting seed may be more susceptible to rupturing.

Host Range

Most all types of beans are susceptible to seedcoat splitting but some varieties are injured more than others.

Environmental Factors

Under favorable conditions, such seeds germinate as well as normal seed. However, if the environmental conditions for germination are not favorable, seeds with split seedcoats usually rot.

Symptoms

Seedcoat splitting can usually be detected early in the development of the ovule by opening the young pod. The cotyledons protrude beyond the seedcoat and somewhat resemble a cone in shape. The exposed area is pointed, roughened, and serrate. The protrusion that generally points toward the pod is affected.

Scouting Procedure/ET

None.

Integrated Control

Non-Chemical Control

Cultural Control: Periodic irrigation during periods of moisture and heat stress will help to reduce the effects of environmental stress on seed development.

Resistant Varieties: Seedcoat splitting is more prevalent in some varieties than others. The tendency for seedcoats to split is heritable and many hybrid lines have been discarded because of the high percentage of split seedcoats.

Chemical Control and Fungicide Resistance: None.

References

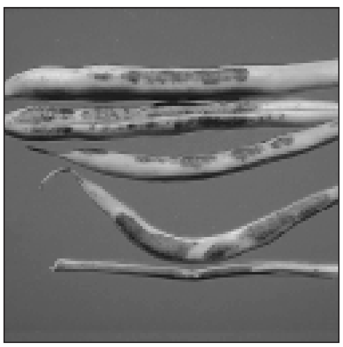
Compendium of Bean Diseases. 1991. American Phytopathological Society Press. St. Paul, MN. 73pp.

Sunscald

Cause: Intense Sunlight

Type: Physiological

Common Name: Light Injury



General Information

Biological Description

Sunscald results from exposure of the plant to intense sunlight. There are no biological factors associated with disease development.

Economic Importance

Sunscald or light injury occurs everywhere in the United States and may affect leaves, stems, branches, and pods of bean plants. Sunscald is most serious when the plant is partly defoliated because of disease, insect, or weather-related injury. Injury usually occurs when bright sunny days follow a prolonged warm, cloudy, and humid period.

Disease Cycle

None.

Host Range

Many types of cultivated and wild plants are affected by sunscald. Among those beans which are injured by intense sunlight are snap bean, lima bean, wax bean, pinto bean, navy bean, and kidney bean.

Environmental Factors

Sunscald injury has been related to periods of intense sunlight and low humidity following periods of high humidity, warm temperatures, and cloudy weather. There also appears to be some association with heavy applications of fertilizers which tend to promote spurts of rapid growth. Succulent leaf tissue which rapidly develops during periods of favorable weather is most susceptible to sunscald injury.

Symptoms

Sunscald affects all aboveground parts of older plants, but the uppermost and outermost areas of the foliage are most sensitive. Symptoms begin on the leaf as a slight browning or bronzing of the epidermis in small patches between the veins, often at the central part of the leaf or sometimes near the margin. In later stages, the discoloration increases in extent and results in the production of large islands of dead tissue. The tissue becomes thin and brittle and crumbles readily when dry. If unfavorable conditions continue long enough, a considerable amount of defoliation may occur. Sunscald causes tiny brown or reddish spots on the parts of pods (russeting)exposed to the sun's direct rays. The spots gradually enlarge and coalesce. In 2 days, they may appear water-soaked, sometimes becoming slightly sunken and often tinged with red.

Scouting Procedure/ET

There is no recommended scouting procedure for this disorder as there are no recommended controls once sunscald has occurred.

Integrated Control

Non-Chemical Control

Cultural Control: Avoid applying excess nitrogen fertilizer. Avoid over irrigation.

Resistant Varieties: Very little work has been done to determine the response of different bean varieties to sunscald.

Chemical Control

None.

Fungicide Resistance: None.

References

Compendium of Bean Diseases. 1991. American Phytopathological Society Press. St. Paul, MN. 73pp.

Hagedorn, D. J. and D. A. Inglis. Handbook of Bean Diseases. A3374. UW-Extension Publication, Wisconsin. 1986. 24 pp.

White Mold

Cause: *Sclerotinia sclerotiorum*

Type: Fungus

General Information

Economic Importance

White mold caused by *Sclerotinia sclerotiorum* is common on many types of plants in most every part of the world. The fungal pathogen is one of the most successful plant pathogens and has been reported on nearly 400 plant species belonging to 64 plant families. The fungus attacks practically all vegetable crops. White mold not only causes crop loss n the field but it can also cause loss to beans in transit.

Disease Cycle

The pathogen overwinters as hard black sclerotia in the soil. Sclerotia range in size from 1/8 to 1/2 inches in length and are produced among the masses of white, cottony growth of mycelium on, and within infected plants. Sclerotia in the top 2-3 cm of soil that have been subjected to a long chilling period, produce apothecia, cup-shaped structures borne singly on the ends of stalks, in which numerous sticky ascospores develop. Soil must be wet for 10 days before apothecia are produced. Once the ascospores are fully mature, low humidity conditions enhance ejection of the spores which may then be carried by the wind to susceptible tissue. Sclerotia may remain dormant in the soil for five or more years.

Host Range

Nearly all vegetable crops are susceptible to infection. A few of the plant species attacked by the white mold fungus include alfalfa, beet, cabbage, cantaloupe, carrot, celery, cucumber, eggplant, dry bean, lettuce, lima bean, onion, peanut, potato, pumpkin, radish, snapbean, soybean, spearmint, sunflower, and tomato. Corn, small grains and grasses have not been reported as susceptible to the fungus.

Environmental Factors

Epidemics of white mold are initiated by ascospores. Sclerotia in the top 2-3 cm of soil that have been subjected to a long chilling period, produce apothecia, a cup-shaped structure which is borne singly on the ends of stalks. Within each apothecia, numerous sticky ascospores develop. Soil must be wet for 10 days before apothecia are produced. Drying of the soil for short periods may prevent apothecia development. Factors affecting soil moisture include relative humidity, wind velocity, temperature, duration of dew, rainfall, irrigation and the density of the plant canopy. Continuous leaf wetness for 48-72 hours is essential for ascospore infection whereas only 16-24 hours are required for infection of the stems, leaves, or pods in contact with moist, infected blossoms. Once the infected bean blossoms dry, 72 hours of leaf wetness are required before the fungus can resume growth and infect new tissues. The duration of leaf wetness and frequency of rainfall or irrigation when inoculum is available is more important than the amount of water received. Optimum temperatures for disease development are 68-77°F.

Symptoms

Young seedlings may be attacked directly by mycelium from soil-borne sclerotia and exhibit symptoms of damping off. Infection is more common, however, after blossoming begins, with symptoms first occurring about one week after bloom. On beans, blossoms are usually the plant part first colonized by the fungus. Stems, leaves, and pods in contact with colonized blossoms are then invaded if sufficient moisture is present. Irregularly shaped water-soaked spots on these plant parts enlarge and a soft watery decay soon follows. A brown, sticky liquid often exudes from infected pods. White, cottony mycelium grows over affected parts if several days of warm, wet weather follow initial infection and sclerotia begin to develop within this mycelial mat. Leaves on affected plants begin to yellow, turn brown, and abscise. Severely infected plants may be killed outright.

Scouting Procedure/ET

There are no recommended scouting procedures developed for monitoring white mold in beans other than to scout areas near the center pivot irrigation system where plants are likely to remain wet for long periods and in poorlydrainede areas.

Integrated Control

Non-Chemical Control

Cultural: Sclerotia survive in soil for at least three years. Although crop rotation with corn, small grains, or grasses is often suggested for control, this practice may not be acceptable for economic reasons in areas of intensive vegetable production. Choose fields with good internal soil drainage and avoid cultural practices which promote excessive canopy growth. Because of the high susceptibility of sunflower to the white mold fungus, do not include sunflower in rotation with snap or lima beans. Use sclerotia-free seed when planting.

Resistant Varieties: Most cultivars of snap beans currently grown in Wisconsin are equally susceptible to white mold.

Chemical Control

There are several chemical fungicides registered for the control of white mold including benomyl, thiophanate methyl and iprodione.

Fungicide Resistance: None.

References

Abawi, G. S. and R. G. Grogan. 1979. Epidemiology of diseases caused by Sclerotinia species. Phytopathology 69:899-904.

Abawi, G. S. and J. E. Hunter. 1979. White mold of beans in New York. Plant Sciences Bulletin No. 77. 4pp.

Prudy, L. H. 1979. Sclerotinia sclerotiorum: History, diseases and symptomatology, host range, geographical distribution, and impact. Phytopathology 69:875-880.

Field Survey of Snap Bean Diseases

General Instructions

1. Sample Site Selection

Three sample sites should be selected for each 40 A field area. Location of each sample site will generally be a compromise between convenience of access and favorability to disease development. Sites in close proximity to windbreaks, isolated trees, or other obstructions are often favorable to disease development since air circulation is often reduced in these areas. In addition, aerial application of pesticides may be impeded by these same obstructions.

2. Sample Site Layout

For each sample site, select four rows ten feet in length, separated by single unscouted rows. Each scouted row should represent approximately 100 to 120 snap bean plants. (See diagram below.)

3. Snap Bean Disease Rating

a) Horsfall-Barratt Rating System

This system is widely used to estimate disease incidence of diseases affecting plant foliage. It is based on the premise that a person's ability to distinguish small differences in percent disease is best near zero or 100% and poorest near 50%. When using this system, scouts should first decide whether disease incidence is greater than or less than 50% of its foliage affected and then select the appropriate rating score that best represents the amount of disease present. The four rating scores recorded at each sample site will be converted to "percent disease" by the IPM staff using a mathematical formula.

Rating scores are based on the percent foliage infected. Include foliage lost (defoliated) due to disease in this rating score. You must decide whether leaf lesions and defoliation are due to the pathogen being rated or another incitant. Collect samples for confirmation if you have difficulty deciding which disease is present.

b) Percentage of Plants Infected

This system is used to record the incidence of diseases affecting individual plants or groups of plants. The system is used wherever information on the degree of severity is not essential.

Disease Rating Score ***(Record on Field Report)***	**Percent Interval of Foliage Infected**
0	No disease observed
1	0 to 3
2	3 to 6
3	6 to 12
4	12 to 25
5	25 to 50
6	50 to 75
7	75 to 88
8	88 to 94
9	94 to 97
10	97 to 100
11	100% All foliage infected.

Sample Site Layout

————————————-------------——————40 feet————--------------------------——————————————

Row 'a'
XXXXXXXXXXXXXXXXXXXXXXXX

Row 'b'
XXXXXXXXXXXXXXXXXXXXX

Row 'c'
XXXXXXXXXXXXXXXXXXXXXX

Row 'd'
XXXXXXXXXXXXXXXXXXXX

———

Permanently flag each sample row such that the same plants in the same rows are rated at each sample period.

Specific Instructions

1. Bacterial Brown Spot

Key

Leaf lesions first appear as tiny water-soaked spots that remain very small and become reddish-brown in color. Pod lesions are sunken, brown, and often surrounded by pale-brown halos. Pod infection may lead to distorted or malformed pods.

Survey Method

All fields—Horsfall-Barratt Disease Rating System. Assign a single disease rating score to each ten-foot sample row each week.

Selected fields—For each ten-foot sample row, select ten primary leaves and ten of the newest, fully expanded trifoliate leaves. Assign a Horsfall-Barratt Disease Rating Score to each leaf. Initiate this procedure when brown spot is first observed and continue until harvest.

For each ten-foot sample row, select 20 pods and rate for presence of brown spot lesions. (+) = lesions present, (-) = lesions absent. Initiate this procedure one week after pod set and continue until harvest.

2. White Mold

Key

Irregularly-shaped water-soaked spots on infected plant parts which enlarge and soon exhibit a soft watery decay. Infection is commonly associated with blossoms or blossom remnants. White cottony mycelium grows over affected plant parts if warm, wet weather prevails. Black sclerotia begin to develop within mycelial mats. Leaves on affected plants begin to yellow and abscise.

Survey Method

Percentage of Plants Infected (eg-2/10)

A weekly survey from full bloom until harvest.

3. Root Rot

Key

Brown semisoft lesions on the lower stem below ground level and root. Lesions may coalesce giving the appearance of a dark brown rot. Sometimes the pith if the stem is destroyed giving rise to the term “hollow stem”.

Survey Method

When plants have 1-3 well-formed pods (#5 size), one foot of row adjacent to each sample row (4 feet from each sample site) should be carefully dug and the roots rated for symptoms of root rot. Rating system: A = healthy (no lesions), B = slight (few root lesions), C = moderate (many toot lesions, but the root does not crush when squeezed), D = severe (top root almost completely rotted, root collapsed or easily crushed when squeezed), E = dead (severely wilted or dead). A single rating will be sufficient. Report data as Rating Number - # of plants in category (e.g. A-1, B-5, C-6, D-5, E-0).

Contents   Sweet Corn (SC)

Verison 2.0 Printed 6/99

UW Extension

Corn Diagnostic Section

The diagnostic guide has been developed to help identify causes abnormal corn. A wide range of corn problems and symptoms encountered throughout the season are included. For each symptom, concise descriptions of the possible causes are listed. Because different problems are associated with different growth stages this guide is divided into the following **four sections**:

1) Before emergence
2) Emergence to Knee-high
3) Knee-high to Tasseling
4) Tasseling to Maturity

Realize that this information is intended as a field identification guide to provide a fast and tentative diagnosis of corn production problems. Many of the causes of problems listed here can be positively identified only through extensive sampling and testing, often only in a laboratory. Therefore, use this diagnostic guide as a preliminary source for problem identification and consult other, more complete sources for positive identification before making any management decisions.

Before Emergence

General appearance	Specific symptoms	Possible causes
Skips in rows plants fail to emerge	No seed planted	▮Planter malfunction ▮Empty planter box ▮Irregular seeding depth
	Seed not sprouted	▮Seed not viable ▮Anhydrous or aqua ammonia injury ▮Excessive fertilizer *(nitrogen and/or potash)* placed too close to seed ▮Soil too dry ▮Toxicity of seed from applied pesticides
	Seed swollen but not sprouted	▮Seed not viable ▮Soil too cold—50º F (10°C) or lower ▮Soil too wet
	Rotted seed or seedlings	▮Fungal seed rots or blights–for description ▮Anhydrous or aqua ammonia injury
	Sprouts twisted or leaves expanded underground	▮Soil crusted ▮Compacted soils ▮Damage from rotary hoe ▮Cloddy soil—allowing light to reach seedling prematurely ▮Seeds planted too deep in cold, wet soil ▮Chloroacetamide Herbicide injury—alachor (Lasso), metolachor (Dual), dimethenamid (Frontier), acetochlor (Harness/ Surpass) or premixes ▮Excessive soil insecticide dosage ▮Anhydrous or aqua ammonia injury
Seed eaten, dug up or sprout cut off	Seed hollowed out	▮Seedcorn maggot ▮Wireworms—sect. ▮Seedcorn beetles–
	Unemerged seedlings dug up and entire plant eaten	▮Mice, groundhogs, ground squirrels, gophers, skunks, rats

Emergence to Knee-high

General appearance	Specific symptoms	Possible causes
Scattered problem spots of dead or poorly growing plants	Uneven growth of corn	▮Drainage problems ▮Soil compaction ▮Variation in planting depth, soil moisture, etc. ▮Poor growing conditions (cold, wet, dry, etc.) ▮Seed bed not uniform (cloddy) ▮Anhydrous or aqua ammonia injury ▮ALS-inhibitor herbicide injury—carryover of previous soybean herbicide or injury from soil applied corn herbicide
	Plants stunted, wilted and/or discolored	▮Nematodes—microscopic, wormlike organisms, several species of which live in the soil and are parasitic on corn roots ▮Damping-off and seedling blight pathogens
	Roots on newly formed crown are discolored and decayed. Limited lateral root development	▮Nematodes ▮Seedling blight pathogens
	Plants cut off above or below ground	▮Cutworms—
	Sudden death of plants	▮Frost in low areas of field, leaves first appear water-soaked, then gray or whitish; if growing point of seedling is still underground or not affected and only top growth killed, plant should recover normally ▮Lightning—both corn and weeds killed, usually in a circular area with clearly defined margins; affected area does not increase in size
Wilting	Upper leaves roll and appear dull or sometimes purple; stunting of plants plants may die	▮Drought conditions ▮Black cutworms—may chew a hole in the stalk below soil surface, which results in the plant wilting and dying ▮White grubs—chew off roots, no tunneling ▮Wireworms—may chew off or bore into roots ▮Corn root aphids—suck the juices from roots; always attended by brown ants ▮Mechanical pruning of roots by cultivator ▮Root and crown rot caused by pathogens
	Whorl leaves dead	▮Wireworms ▮Cutworms ▮Stalk borer ▮Hop vine borer ▮Bacterial stalk rotlk rot
	Crown roots not developing	▮Dry surface soil, shallow planting, wind

Emergence to Knee-high

General appearance	Specific symptoms	Possible causes
Plants discolored	Leaves appear sandblasted; leaves pale green or whitish in color	▮Wind damage—blowing sand and soil ▮Spider mites—feed primarily on underside of leaves; produce fine webbing across leaf surfaces; most destructive during hot, dry weather
	Lower leaves with speckles or spots of dead tissue, new growth undamaged	▮Herbicide injury—postemergence contact herbicides, either photosynthetic inhibitors or membrane disrupters
	General yellowing of upper leaves	▮Magnesium deficiency
	General yellowing of lower leaves	▮Excessive moisture
	Yellowing in the whorl, may present as yellow/translucent regions on these leaves after they emerge	▮Herbicide injury—from postemergence ALS-inhibitor herbicide or low dose of ACCase-inhibitor
	Purpling or reddening of leaves from tip backward; affects lower leaves initially, leaf tips may later turn dark brown and die	▮Phosphorus deficiency—severe ▮Compacted soil ▮Cold weather ▮White grubs ▮Dinitroaniline herbicide injury—check for clibbed root tips
	Leaves of seedlings bleached white	▮Herbicide injury—Command carryover, Balance injury, low dose of Roundup Ultra
	Irregular light and dark mottling or mosaic at base of whorl leaves	▮Maize dwarf mosaic or Maize chlorotic dwarf virus
	Irregular light gray or silvery blotches on both sides of leaves on the east side of affected plants	▮'Sunscald'—usually occurs when chilly, dewy nights are followed by sunny mornings ▮Frost
	Light streaking of leaves which develops into a broadband of bleached tissue on each of the midribs; leaf midribs and margins remain green; sometimes stalks and leaf edges appear to be tinted red or brown	▮Zinc deficiency
	Bright yellow to white stripes with smooth margins running the length of leaves; may appear on scattered plants throughout the field and sometimes only on one side of a plant	▮Genetic stripes
	White or yellow stripes between leaf veins	▮Excessively acidic soil ▮Magnesium deficiency ▮Maize white line mosaic virus–if white lines are not continuous
Plants discolored	Distinct bleached bands across leaf blades; leaf tips may die back; leaf tissue may collapse at discolored bands, resulting in the leaf folding downward at this point	▮Air pollution injury

Emergence to Knee-high

General appearance	Specific symptoms	Possible causes
Plants discolored and stunted	Leaves yellow; plants spindly and stunted	▮Nitrogen deficiency ▮Sulfur deficiency—more pronounced on younger leaves than nitrogen deficiency
	Purple or red discoloration of leaves, especially leaf margins; stunting; stubby, malformed roots sometimes confused with injury by nematodes	▮Dinitroaniline herbicide injury—trifluralin(Treflan), pendimethalin (Prowl) Usually results from excessive rates, carryover from the previous year's application for soybeans or sunflower production or if pendimethalin applied to shallow planted corn; causes stubby roots with tips swelling and restricted secondary root development. ▮Phosphorus deficiency—mild
Plants discolored, malformed and/or stunted	Excessive tillering; stunting	▮Crazy top—fungal disease
	Slight yellow-green tint; severely stunted; inability of leaves to emerge or unfold–leaf tips stick together, giving plants a ladder-like appearance	▮Calcium deficiency ▮Herbicide injury—Chloroacetamide herbicide (Lasso, Dual, Frontier, Surpass, Harness); Thiocarbamate herbicides (Eradicane)
	Leaves yellow and not fully expanded; roots sheared off or dried up	▮Overapplication of anhydrous or aqua ammonia
Plants stunted and/or malformed	Leaves fail to unfurl properly, often leafing out underground; plants may be bent, lying flat on the soil surface	▮Excessive Chloroacetamide herbicide rates—(Lasso, Dual, Frontier, Surpass, Harness)
	Leaves stunted—twisted, and may appear knotted	▮Thiocarbamate herbicide injury—(Eradicane)
	Shoots and roots stunted and/or onion-leafing (leaves remain wrapped in a tall spike)	▮Growth regulator herbicide (2,4-D, Banvel, Clarity) applied pre-emergence on coarse textured soil or to shallow planted corn, roots may also be short and thick
	Plants bent or twisted	▮Growth regulator herbicide (2,4-D, Banvel, Clarity) applied post-emergence
	Plants bent or twisted; stunted; irregular rows of holes in unfolded leaves	▮Stalk borer ▮Billbugs
Lesions on leaves	Oval, circular or rectangular lesions on leaves	zNorthern corn leaf spot—
	Long lesions (1-8 in.) that taper at ends	▮Northern corn leaf blight—
	Long, irregular yellow to brown streaks in leaves	▮Stewart's bacterial leaf blight—
	Tan to spindel-shaped lesions with parallel sides and buff to brown borders	▮Southern corn leaf blight—
	Oblong, oval, tan-colored spots with considerable yellowing of leaves	▮Yellow leaf blight—

Emergence to Knee-high

General appearance	Specific symptoms	Possible causes
	Brown, oval lesions; yellow to reddish-brown	▮Anthracnose leaf blight—
	Very small, yellow to brown spots in bands near leaf base	▮Physoderma brown spot—
	Small (1-4 mm), translucent, circular to oval lesions	▮Eyespot—
	Brown opaque, rectangular lesions (½-2 in.) between veins; lesions do not taper	▮Gray leaf spot
	White dried areas between leaf veins	▮Air pollution injury
	Dull, gray-green, water-soaked lesions that develop into white dry areas on leaf surfaces; oldest leaves may show the injury symptoms at their bases, next oldest leaves across their middles, and the youngest leaves at their tips; leaf margins most severely injured; midribs remain undamaged; NOTE: sweet corn is much more susceptible than field corn	▮Air pollution injury
	Yellow mottling along leaf margins and tips; small, irregular yellow spots develop between veins and may form continuous yellow bands	▮Air pollution injury
Plant tissue removed	Whole plant cut off at ground level	▮Back cutworm—
	`Leaves entirely eaten off or large chunks of leaf tissue removed	▮Armyworms— ▮Grasshoppers—
	Ragged holes in leaves	▮Hail damage ▮Slugs— ▮European corn borers— ▮Black cutworms—early larval instar damage
	Shredding, tearing of leaves	▮Wind damage ▮Hail damage
	Rows of circular to elliptical holes across leaves	▮Billbugs— ▮European corn borers— ▮Stalk borers—
	Irregular brown lines or 'tracks' scratched from the top layer of leaf tissue; heavily infested leaves may appear gray in color, shrivel and die	▮Corn flea beetles—
	"Window effect" of leaves—interior of leaves (area between upper and lower surface) eaten out, leaving a transparent 'mine' with bits of dark fecal material scattered throughout	▮Corn blotch leaf miners—

	Yellowed and weakened area on leaf midrib from tunneling feeding damage; often frass (sawdust-like excrement) evident around the feeding wound; the midrib will commonly break at this point, causing the leaf blade to fold down from the damaged area	▮European corn borers—

Knee-high to Tasseling

General appearance	Specific symptoms	Possible causes
Severe wilting and/or death of plants	Sudden death of plants	▮Lightning—All plant material in an approximately circular area suddenly killed; plants along margin of affected area may be severely to slightly injured; severely injured plants may die later
	Dieback of leaves, wilting, then drying up of leaf tissue, beginning at leaf tips	▮Molybdenum deficiency—younger leaves may twist ▮Air pollution injury
Plants discolored	Yellowing of plants, beginning with lower leaves	▮Nitrogen deficiency—V-shaped yellowing of leaves, beginning at midrib and widening toward leaf tips; leaf tips die ("firing") while leaf margins remain green ▮Drought conditions—produce nitrogen deficiency ▮Ponded conditions—standing water can produce nitrogen deficiency
	Yellowing of leaf margins, beginning at tips; affected tissue later turns brown and dies	▮Potassium deficiency
	Purpling or reddening of leaves from tip backward; affects lower leaves initially; leaf tips may later turn dark brown and die	▮Phosphorus Deficiency
	Yellow to white interveinal striping on leaves	▮Genetic stripe—stripes have smooth margins; may appear on scattered plants throughout the field and, sometimes, only one side of a plant ▮Magnesium deficiency—yellow to white striping usually developing on lower leaves; red-purplediscoloration along edges and tip; stunting may occur ▮Boron deficiency—initially white, irregularly shaped spots develop between veins which may coalesce to form white stripes that appear waxy and raised from leaf surface; plants may be stunted
	Pale green to white stripes between leaf veins, usually on upper leaves	▮Iron deficiency

	Upper leaves show pale green to yellow interveinal discoloration; lower leaves appear olive green and somewhat streaked; severe damage appears as elongated white streaks, the center of which turn brown and fall out	▮Magnesium deficiency
Plants discolored and malformed	Plants show stunting and/or a mottle or fine chlorotic stripes in whorl leaves	▮Maize dwarf mosaic or Maize dwarf chlorotic
	Stunting, tillering; twisting and rolling of leaves;	▮Crazy top—fungal disease
Plants malformed	Plants "rat-tailed"—leaf edges of top leaf fused so leaves cannot emerge	▮Growth regulator herbicide (2,4-D, Banvel, Clarity) applied post-emergence with an ALS-inhibitor herbicide to seedling corn ▮Mechanical injury
	Leaves tightly rolled and erect	▮Growth regulator herbicide (2,4-D, Banvel, Clarity) applied at high rates or excessive spray in the whorl after 8 inches tall ▮Drought stress
	Plants lodge or grow up in a curved 'sledrunner' or 'gooseneck' shape	▮Corn rootworm larvae feeding damage—damaged root systems result in entire plant becoming lodged; stalk breakage (lodging) does not result from rootwom damage ▮Nematode feeding damage—microscopic worm-like organism, several species which live in the soil and are parasitic on corn roots ▮Previous herbicide injury that had pruned root system—dinitroaniline or growth regulators ▮Mechanical injury ▮Hot, dry weather and winds—preventing normal brace root development
	Brown, soft rot of a lower internode; stalks twist and fall	▮Pythium stalk rot or bacterial stalk rot ▮European corn borers—stalks weakened by borer feeding damage ▮Stalk borer
	Fused braced roots	▮Growth regulator herbicide (2,4-D, Banvel, Clarity) applied after 8 inches tall
	Soft, glistening white galls that soon become black and dusty; appears on stalks, leaves, ear or tassel	▮Common smut—
Plant tissue removed	Ragged holes in the leaves, shredding of plants	▮Hail damage
	Shredding, tearing of leaves	▮Wind damage
	Green upper layer of tissue stripped from leaves	▮Western corn rootworm beetles—
	Window effect on leaves—interior of leaves (area between upper and lower leaf surfaces) eaten out, leaving a transparent 'mine' with bits of dark fecal material scattered throughout	▮Corn blotch leafminers—

Knee-high to Tasseling

General appearance	Specific symptoms	Possible causes
Plants tissue removed *(continued)*	Leaves entirely eaten off or large chunks of leaf tissue removed	▮Armyworms— ▮Grasshoppers— ▮Fall armyworm— ▮Livestock
	Holes bored into stalks and area within stalk hollowed out by feeding damage	▮European corn borers—late instar damage ▮Stalk borers
Lesions on plants	Oval, circular or rectangular lesions on leaves	▮Northern corn leaf spot—
	Long lesions (1-8 in.) that taper at ends	▮Northern corn leaf blight—
	Brown opaque, rectangular lesions (½-2 in.) between veins; lesions do not taper	▮Gray leaf spot
	Tan, oval to circular lesions	▮Holcus bacterial spot ▮Fungal leaf spots ▮Paraquat herbicide injury
	Irregularly or wavy-margined, pale green to yellow or pale brown streaks; in Corn Belt usually after tasseling	▮Stewart's bacterial leaf blight
	Tan leaf lesions with parallel sides or spindle shaped with buff to brown borders; in Corn Belt usually after tasseling	▮Southern corn leaf blight
	Long, elliptical gray-green or tan lesions developing first on lower leaves; in Corn Belt usually after tasseling	▮Northern corn leaf blight
	Very small, yellow to brown spots in bands near leaf base	▮Physoderma brown spot
	Yellow mottling along leaf margins and tips; small irregular, yellow spots develop between veins and may form continuous yellow bands	▮Air pollution injury
	Interveinal tan to yellow streaks on leaves	▮Air pollution injury
	White dried areas between leaf veins; severe injury may cause tip dieback	▮Air pollution injury
	Dull, gray-green, water-soaked lesions that develop into white dry areas on leaf surfaces; oldest leaves may show the injury symptoms at their bases, next oldest leaves across their middles, and the youngest leaves at their tips; leaf margins most severely injured; midribs remain undamaged; *NOTE: sweet corn is much more susceptible than field corn*	▮Air pollution injury
	Brown, oval lesions with yellow to reddish-brown borders	▮Anthracnose leaf blight—

	Irregular to elliptical, brown, water-soaked leaf spots	▮Bacterial leaf spot and stripe
	Small, circular tan spots with brown to purple margins	▮Eyespot—
	Circular to oval, brown to black pustules on leaves	▮Common corn rust

Tasseling to Maturity

General appearance	Specific symptoms	Possible causes
Silking impaired	Delayed silking or failure to silk	▮Stress on plants earlier in the season ▮Plant population too high ▮Nutrient deficiency ▮Corn leaf aphids—typically found in large numbers feeding within the whorl
	Silks clipped off	▮Corn rootworm beetles—two species attack corn: northern and western and ▮Grasshoppers
Tassels malformed	Tassels fail to emerge	▮Boron deficiency
	Tassels, upper stalk and foliage bleached; premature drying	▮Anthracnose
	Tassels develop as a mass of leaves	▮Crazy top
Ears replaced by leaves	Leafy condition at ear node	▮Crazy top
Plants discolored	Yellowing of leaf margins, beginning at tips; affected tissue later turns brown and dies	▮Potassium deficiency
	Irregular, purple-brown spots or blotches on sheaths	▮Purple sheath spot
Stalks malformed and/or broken	Lower stalk internodes easily compressed; stalks may lodge (break over); pith tissue destroyed	▮Diplodia stalk rot ▮Charcoal stalk rot ▮Gibberella stalk rot ▮Fusarium stalk rot
Stalks malformed and/or broken *(cont'd.)*	Lower internodes easily compressed; black linear streaks on stalk surface	▮Anthracnose stalk rot
	Plants lodge, stalk may break	▮European corn borer ▮Potassium deficiency—yellowing of leaf margins, beginning at the tips; affected tissue later turns brown and dies

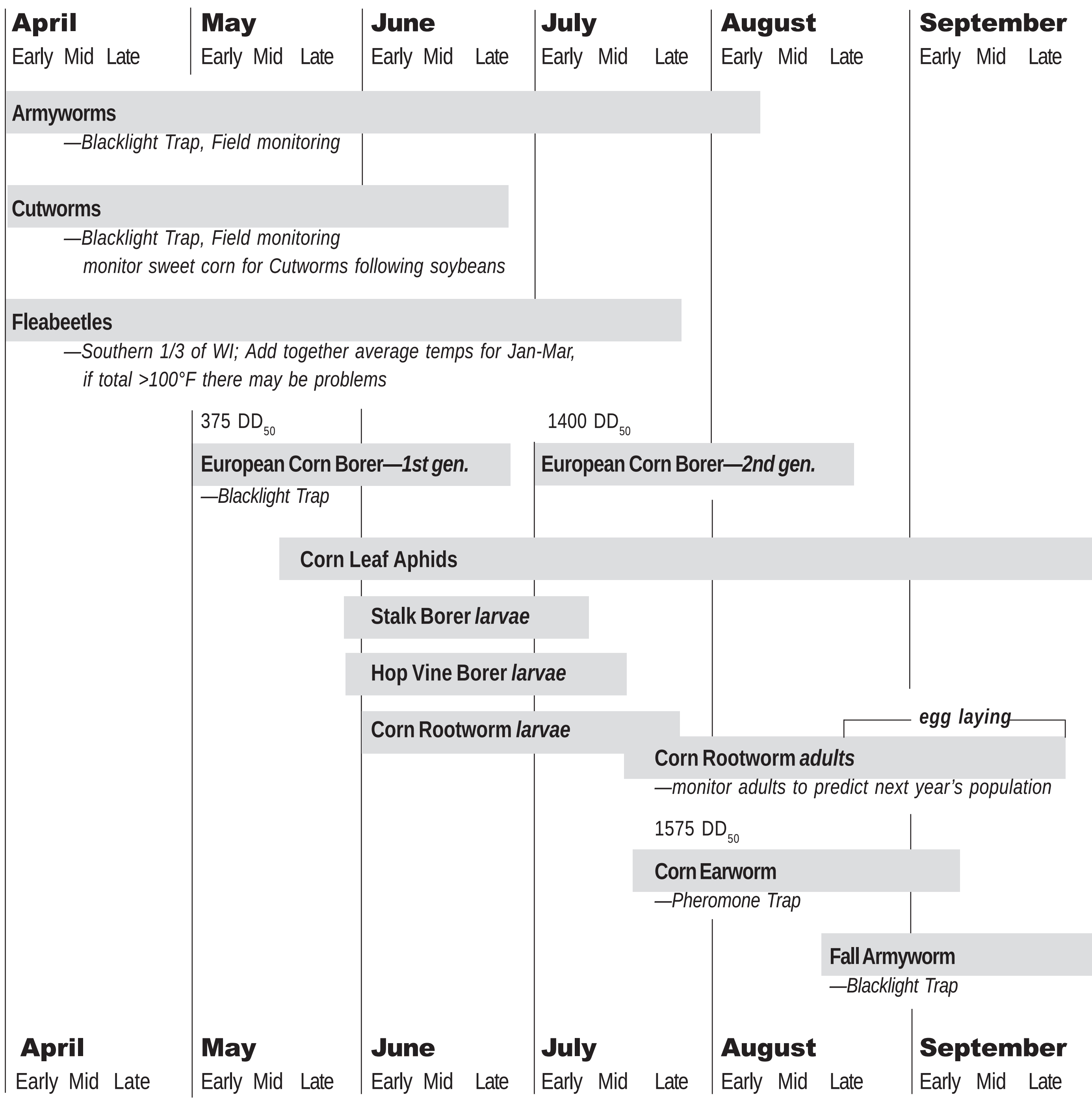
Tasseling to Maturity

General appearance	Specific symptoms	Possible causes
Premature death of all or some parts of plants	Sudden death of entire plant	▮Stalk rot complex ▮Lightning—all plant material in an approximately circular area suddenly killed; plants along margins of affected area may be severely to slightly injured; severely injured plants may die later ▮Frost—before plants reach maturity—eaves first appear water-soaked, then gray; plants in low areas of fields most susceptible
	Extensive areas of leaf tissue die prematurely resulting in leaf drying	▮Air pollution injury ▮Stewart's Bacterial leaf blight ▮Northern corn leaf blight ▮Anthracnose leaf blight
	Top kill—premature death of all or portion of plants above ears	▮Anthracnose
Leaf tissue removed	Ragged holes in the leaves	▮Hail damage
	Shredding, tearing of leaves	▮Wind damage
	Small, irregular holes in leaves	▮European corn borer—second brood larval feeding
	Large, irregular holes in leaves	▮Grasshoppers ▮Fall armyworms
Plants discolored or stunted	Slight to severe stunting; yellowing and sometimes reddening of foliage	▮Maize dwarf mosaic/Maize chlorotic dwarf
Lesions on leaves	Tan leaf lesions with parallel sides or spindle-shaped and buff to brown borders	▮Southern corn leaf blight
	Long, elliptical, gray-green or tan lesions	▮Northern corn leaf blight
	Small brown to red-brown spots to irregular blotches in bands	▮Physoderma brown spot
	Small (1/16 to 3/8 inch) circular to oval lesions	▮Eyespot
	Elongate, irregular brown water-soaked leaf stripes or spots on lower leaves	▮Bacterial leaf spots and stripe
Lesions on leaves *(cont'd.)*	Oval, circular or rectangular lesions on leaves	▮Northern corn leaf spot
	White, dried areas between leaf veins	▮Air pollution injury—severe injury may cause premature maturity
	Circular to oval lesions, brown centers with yellow to orange borders	▮Anthracnose leaf blight
	Numerous brown to black pustules on any above ground part, especially the leaves; leaves dry out	▮Common corn rust

Damaged or malformed ears area plant	Dark 'bruises' on husks	▮Hail damage—all plant material in an affected; often more severe on one side of
etc.) after reaching	Pinched ears	▮ALS-inhibitor herbicide (Accent, Beacon, applied broadcast "over-the-top" the V6 stage
Banvel,	Ears with missing kernels	▮Growth regulator herbicide (2,4-D, Clarity) applied at tasseling
	Large chunks removed from husks and ears;	▮Grasshoppers ▮Birds—ears often upright, husks shredded ▮Rodents, raccoons, squirrels or other animals; stalks often pulled over, husks shredded or pushed back
Brown mold at base of ear	White to pink mold starting at ear tip; husk rotted	▮Gibberella ear rot
	White to pink mold on individual kernels	▮Fusarium ear rot ▮Diplodia are rot

Scouting Calendars

Sweet Corn Insect Scouting Calendar



Sweet Corn Disease Scouting Calendar

Diseases	Temperature	Climate	Occurrance
Maize Dwarf Mosaic		mild winters (favors aphids)	emergence to tasseling
Anthracnose	60-90°F	high humidity	emergence to maturity
Rust	60-68°F	high humidity	emergence to maturity
Stewart's Disease	high temperatures	dry weather, mild winters (favors fleabeetles)	emergence to maturity
Common Smut	79-93°F		kneehigh to tasseling

Corn Growth Stages & Morphology

Identifying corn growth stages is necessary for post-emergence application of pesticides or growth regulators, to monitor the progress of seasonal development, or to determine the effect on yield from a hail storm, insect feeding, disease, drought or early frost.

A superb publication on this topic is *How a Corn Plant Develops*, Special Report No. 48, Iowa State University. This paper and attached tables summarizes major points from this bulletin.

Developmental stages before pollination are called vegetative stages and are determined by counting the number of leaves produced by the plant. If 5 leaves are developed on more than 50% of the plants in a field, the field is in the 5-leaf stage. The Iowa State System defines leaf stages according to **the uppermost leaf whose collar is visible**. Under this system, for example, the 5-leaf stage is termed V5, for vegetative 5-leaf stage. Another slightly different system is used by the National Crop Insurance Association (NCIA), which defines leaf stages according to **the uppermost leaf with its tip pointing below a horizontal line**. The two systems cannot be used interchangeably—plants at the V5 leaf stage under the Iowa System are usually at the **seventh leaf** stage using the NCIA system. In order to avoid confusion it is best to define exactly how the indicator leaf is identified, regardless of which system is used. The attached tables provide a general comparison of leaf stage designations for the two systems.

For all the vegetative stages between V1 and V5 (Iowa system) or first leaf and seventh leaf (NCIA system), leaves can be counted starting with leaf one, which has a rounded tip and is the lowest leaf on the stalk. All other leaves have a pointed tip.

With stem growth and brace root development, the lower 6 leaves slough from the corn plant. Soon after V6 (Iowa system) or eighth leaf (NCIA system), the first leaf with the rounded tip senesces and the stalk must be split to determine the stage of the remaining leaves. For plants without the rounded tip on the lowest leaf, split the stalk to identify the first elongated internode. Leaf number 5 is attached to the node immediately above. Using this reference point, count the number of leaves which have developed.

Vegetative stages range from ***VE*** to ***V18*** or ***V19*** (Iowa system) or ***emergence*** to ***18th*** or ***19th*** leaf (NCIA system) for most of Wisconsin hybrids. Early maturing hybrids may develop 1 to 2 fewer; late hybrids develop 1 to 2 more leaves.

Reproductive stages are designated ***R1*** to ***R6*** for the Iowa system and ***silking*** to ***mature*** with the NCIA system, and are based on kernel development.

The attached tables compare the two staging systems, and summarize average length of time in various stages, as well as characteristics and developmental events.

Iowa State System	NCIA System	Days in Stage *(average)*
VE	gemination	10
	emergence	4
	first leaf	3
	second leaf	3
V1	third leaf	3
V2	fourth leaf	3
V3	fifth leaf	3
V4	sixth leaf	3
V5	seventh leaf	3
V6-V8	etc.	3
V9-V11	etc.	2-3
V12-V14	etc.	2
V15-Vn	etc. to nth leaf*	1-2
VT	tasseled	4

Iowa State System	NCIA System	Days in Stage *(average)*	Days after Silk *(average)*
R1	pollen shed/ silking	4	0
	silks brown	5	
	pre-blister	4	
R2	blister	4	10-14
	early milk	4	
R3	milk	5	18-22
	late milk	4	
R4	soft dough	5	24-28
	early dent	5	
R5	full dent	5	35-42
	1/2 milk stage	10	
R6	mature		55-65

* nth leaf = flag leaf, n = 16-18 for **early** hybrids *(less than 100-day)*; n = 18-21 for **medium-late** hybrids *(100 to 110-day)*

Iowa State System	NCIA System	Developmental Events
VE	germination	Seed absorbs water, begins growth. Radicle elongates, followed by coleoptile with enclosed plumule emergence (embryonic plant) and then seminal roots. Mesocotyl elongation pushes coleoptile to ssoil surface.
  V1 V2	first leaf second leaf third leaf fourth leaf	Growing point is 1-1½ inches below soil surface (just above seed). Embryonic leaves grow through coleoptile tip and begin above-ground plant development. Seminal root system is functional, nodal root system initiated.
V3 V4 V5	fifth leaf sixth leaf seventh leaf	Leaf and ear shootinitiation complete by V5 and tassel is initiated at stem (growing point) apex. Growing point still below soil surface. Seminal root system growth ceases.
V6-V8	etc.	Growing point and tassel above soil surface by V6. Stalk beginning rapid elongation. Nodal root system is major functional root system. Last chance to sideress N before rapid uptake period without root pruning. Loss of two lower leaves occurs by V8.
V9-V11	etc.	Rapid tassel development and rapid stalk elongation. Soil ntrient and water uptake is rapid. Many ear shoots visible, at several lower nodes. Lower ear shoots most developed and lergest.
V12-V14	etc.	Potential ear size (rows/ear) already established. Ear length (kernels/row) development continues until Vn. Top ear shoot (6-8 nodes below tassel) still smallest.
V15-Vn	etc. to nth leaf	Upper ear shoot development surpasses lower ear shoots. Only 1-2 upper ears normally develop further. Silks (under husk) begin growth from upper ears. Brace roots growing from nodes above soil surface.
VT	tasseled	Full plant height nearly attained. Roots reach greatest depth and total length. Plant is mostvulnerable to hail, moisture or nutrient stress for next two weeks.
R1	pollen shed/ silking silks brown	Pollen shed occurs mostly during late mornig and early evening. Pollen grains grow down silk to fertilize ovules. Ovules that are not fertilized will degenerate. Environmental stress causes poor pollination and seed set. Potassium uptake is nearly complete, N & P uptake are rapid.
R2	pre-blister blister	Shank and husks reach full size. Kernel embryo visible upon dissection. Starch accumulate rapidly in kernels and continues until R6. Relocation of N & P from leaves and stalks to ear begins.
R3	early milk milk late milk	Cell division within endosperm complete. Growth due now to cell expansion and filling cells with starch.
R4	soft dough early dent	Embryo development nearly complete. Kernels about 70% moisture and close to half of mature dry weight.
R5	full dent	Hard starch layer (milk line) forms at top of kernel and moves toward base. Kernels have about 55% moisture content at beginning of R5 and 75-85% of mature dry weight.
R6	½ milk stage mature	90-95% of mature dry weight accumulated. Maximum dry weight attained (physiological maturity). Frost or other stress will not affect final grain yield.

Iowa State System	NCIA System	Diagnostic Characteristics
VE	germination	seed planted
	emergence	Coleoptile above soil surface
	first leaf	40 to 50% of first actual leaf exposed
	second leaf	40 to 50% of second actual leaf exposed
V1	third leaf	40 to 50% of third actual leaf exposed; collar of first leaf visible
V2	fourth leaf	40 to 50% of fourth actual leaf exposed; collar of second leaf visible
V3	fifth leaf	40 to 50% of fifth actual leaf exposed; collar of third leaf visible
V4	sixth leaf	40 to 50% of sixth actual leaf exposed; collar of fourth leaf visible
V5	seventh leaf	40 to 50% of seventh actual leaf exposed; collar of fifth leaf visible
V6-V8	etc.	etc.
V9-V11	etc.	etc.
V12-V14	etc.	etc.
V15-Vn	etc. to nth leaf	At nth leaf stage, collar of flag leaf is visible; tassel and ear shoot emerging, but not fully extended
VT	tasseled	Tassel fully extended; ear shoot exposed but no silk showing; no pollen evident
R1	pollen shed/ silking	Silks have emerged; tassel is shedding pollen
	silks brown	Pollination almost complete; 75% of silks brown in color, but not dry to touch
	pre-blister	Silks all brown; kernel very small 'pimple'
R2	blister	Kernels appear as watery blisters
	early milk	Beginning of 'roasting ear' stage; kernels changing from white to yellow.
R3	milk	Prime 'roasting ear' stage; kernels full yellow color; cob maximum length
	late milk	Milky fluid thickening and solids forming in base of kernels
R4	soft dough	Past prime roasting stage; semi-solid, but milky substance can be squeezed out
	early dent	Kernels along entire ear beginning to dent
R5	full dent	Most all kernels dented; kernel easily cut with fingernail; milk in tip of some kernels
	½ milk stage	Milk-line is midway between tip and base of kernel; kernel moisture is 40%
R6	mature	All milk has disappeared from kernels; black layer is usually present; kernel moisture is approximately 30-35%

Crop Injury Ratings of Herbicides on Corn

Herbicides[abcd]

Preplant–incorporated

Acetanilides + atrazine premixes [d]	VS
Acetochlor	VS
Alachlor	VS
Dual II	VS
Frontier	VS
Atrazine	N
Broadstrike + Dual	S/M
DoublePlay	VS
Eradicane	VS
Pursuit [e]	VS

Preemergence

Acetanilides + atrazine premixes [d]	VS
Acetochlor	VS
Alachlor	VS
Dual II	VS
Frontier	VS
Atrazine	N
Bladex	S
Broadstrike + Dual	S/M
Dicamba	S
Extrazine II	S
Hornet	S/M
Marksman	S
Prowl	S
Pursuit [e]	VS
Pursuit Plus[e]	S

Postemergence

Accent	S
Atrazine & oil	VS
Basagran	VS
Basis	S/M
Basis Gold	S/M
Beacon	S
Bladex	M
Buctril	S
Buctril+atrazine	S
Dicamba	S/M
Exceed	S
Hornet	S
Laddok S-12	VS
Liberty [f]	VS
Lightning [e]	S
Marksman	S/M
Permit	VS
Resolve [e]	S
Resource	S
Scorpion III	S
Stinger	VS
Tough	VS
2,4-D	M

[a] These herbicides have been rated for expected weed control, but actual results may vary depending upon rates applied, soil types, weather conditions, and crop management.

[b] Crop injury: M=moderate; S=slight; VS=very slight; N=none.

[d] Acetanilide + atrazine premixes include Bicep Lite II, Bullet, Guardsman, Harness Xtra, Lariat, and Surpass 100.

[e] Lightning, Pursuit, Pursuit Plus, and Resolve can only be used with IR or IT corn hybrids.

The above information is from (A3646) *1997 Field Crops Pest Management in Wisconsin; A Guide to managing weeds, insects, and diseases in corn, soybeans, forages and small grains*, and is reprinted with permission from the Cooperative Extension Publications, University of Wisconsin-Extension.

Techniques and Equipment

Scouting Corn: A guide to efficient pest scouting

J. Doll, C. Grau, B. Jensen, J. Wedberg, J. Meyer

Introduction

Field monitoring, or scouting, is the backbone of all pest management programs. Before appropriate pest control decisions can be made, a detailed assessment of pest populations must be obtained. Efficient pest scouting requires a thorough knowledge of pest and crop biology, pest identification and habits, correct sampling methods, and economic thresholds (when available). The goal of scouting is to give a complete, accurate and unbiased assessment of pest populations. The field scout is the link between the consultant and grower. Scouting report forms must be comprehensive enough so control decisions can be made directly from the report form. These forms not only serve as a record of current pest populations but should be saved by the growers or consultant as part of the field history records.

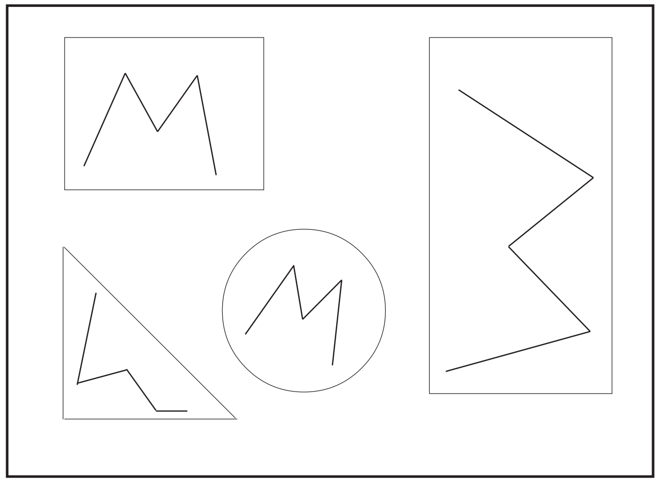


Figure 1: Suggested field patterns

Scouting Frequency

The frequency with which visits must be made depends on the type of crop grown and pest(s) present or expected. Field visits must be scheduled such that increases in pest populations are detected as soon as economic thresholds are reached.Field corn should be monitored at weekly intervals until pollination is completed, at which time scouting frequency can be relaxed to approximately once every ten days. At this time there is little danger of pest levels exceeding the economic threshold level between visits. The field scouts, however, should always have flexible schedules to allow revisiting problem fields.

Scouting Patterns

Before a scout enters a field an appropriate route must be planned. For efficiency sake, an M-shaped walking pattern is best used on square or rectangular shaped fields. In irregularly shaped fields scouts must keep in mind that they must cover a representative area of the field. Consult Figure 1 for suggested field patterns. You cannot scout one edge of the field and expect pest populations to be the same in other areas. Do not sample the edge of a field unless it is specifically recommended (i.e. stalk borer or weed scouting). Often pest populations found on the field edge do not indicate what is present in the rest of the field. The exception, of course, is contour strips, where the whole strip can be considered "edge." When scouting contour strips, walk the middle of the contour and zig-zag back and forth. Each individual strip must be scouted separately because the types of pest found as well as degree of infestation may vary from strip to strip.

The number of times a scout must stop to make specific counts will vary according to the type of pests found and will be discussed later in this bulletin.
For large fields (greater than fifty acres), the scout's accuracy diminishes to the point where a field of this size or larger should be split into two separate fields. Separate fields according to geography, previous cropping history or soil type.

Field History Forms

Before the scouting season begins, growers should complete a Field History Form (Appendix A). It should contain such information as field location, cropping history, crop yields, pesticide use, fertilizer and lime applications, soil type, soil test records, major pest problems, and anything else that could make scouting more effective.

Scouting Report Forms

Whenever a field is scouted, a field report form (Appendices B or C) should be filled out and a copy left with the grower. Even if damaging levels of pests are not found, farmers are still interested in general crop health and growth stage. These forms should be filled out in triplicate with copies given to the grower, scout supervisor, and a copy should stay with the scout. As scouts prepare to walk individual fields, they should familiarize themselves with past reports so problem areas can be closely monitored.

Equipment

When monitoring corn a scout should carry the following equipment:

- scout report forms and clipboard pencil(s)
- pocket knife (for splitting stalks and cutworm scouting)
- magnifying glass or hand lens for accurate pest identification
- bags, plastic vials and labels (for collecting plant and insect specimens for future identification)
- mechanical hand counter
- measuring tape

In addition the scout should have available in their vehicle:

- reference materials (in case problems are encountered in the field)
- spade (for digging entire plant for pest identification)
- cooler with ice (to keep unknown weed, insect and disease samples fresh until accurate identification can be obtained

Stand Counts

Stand counts should be made the second week after emergence. Count the number of plants in 20 linear feet of row from five randomly selected areas of a field. Measure the distance between rows in several locations within the field. Multiply the total number of plants counted in the 100 feet of row by the appropriate conversion factor (Table 1) to determine plant population.

Row Width	Conversion Factor
30 inches	174
36 inches	145
38 inches	138
40 inches	131

For example, if you have counted a total of 145 plants and the row width was 30 inches, multiply 145 (plants) x 174 (conversion factor) = 25,230 plants per acre.

Table 1: Conversion factors to determine corn populations

Weed Scouting Procedure

The first weed survey should occur shortly after corn emergence and continue at weekly intervals until control options are no longer available. Scouts should record the relative weed abundance and growth stages at ten randomly selected sites. When moving between sites always look for pockets of problem weed infestations. Mark their location on a weed map (Appendix D) so growers can spot treat these areas if necessary. Continue adding to this weed map as the season progresses. This map should be as accurate as possible and include field boundaries and other points of reference (i.e. waterways, access roads and buildings).

Scouts can group individual weed populations into these four categories:

Scattered-Weeds present but very few plants within the field. Enough plants to produce seed but not likely to cause economic loss in the current year.

Slight-Weeds scattered throughout the field, an average of no more than 1 plant per 3 feet of row, or scattered spots of moderate infestations. Economic loss unlikely but possible in certain areas.

Moderate-Fairly uniform concentration of weeds across the field. Average concentrations of no more than 1 plant per foot of row or scattered spots of severe infestations. Economic loss likely unless control measures taken.

Severe-More than 1 plant per foot of row for broadleaf weeds and 3 plants per foot of row for grasses, or large areas of heavy infestations. Economic loss certain unless weeds controlled.

We do not have exact threshold numbers on a species by species basis at this time. Common sense and intuition should be the guides to determine the course of action in a given field.

Perennial broadleaves like Canada thistle, hemp dogbane, bindweeds, and Jerusalem artichoke usually occur in scattered patches. Yield loss in these areas can be very serious. The decision of what action is appropriate will be based on the percentage of the field infested, weed and crop growth stage, and distribution pattern of the patches.

In addition to yield losses, certain weeds can interfere greatly with harvest. Bindweeds and giant ragweed are examples of weeds that should be controlled regardless of their impact on corn yield as they can greatly reduce harvest efficiency and increase machinery repair costs.

A comprehensive weed survey/map should be completed by the end of the scouting season. Growers can then develop a preventative weed control program, if necessary, based on weeds most likely to be present next season.

Corn Disease Scouting

Corn should be monitored for evidence of disease during each field visit. If seedling blights are present during the early season scouting, determine percent of plants infected by looking at 20 plants in each of five randomly selected areas within a field.

For leaf diseases, general remarks should be noted as to crop stage, percent of plants affected, percent of foliage infected, whether the disease is above or below the ear, and the location of the infestation within the field. Stalk rots evaluation should be treated differently. Use either the "squeeze test" (squeezing the lower internodes between thumb and forefinger, if tissue collapses then stalk rots are likely to be present) or the "push test" (pushing the plant 6-8 inches off vertical center, if it breaks between the ear and lowest node then stalk rots are likely present) to determine if plants are infected. Conduct either test on 20 plants in each of five randomly selected areas of a field. Report to grower which of the stalk rots are likely the cause and an average percent infestation. Stalk rot tests should begin about four weeks after tasseling. If a fall scouting is conducted, examine for ear rot infestation. Strip back husks from 10 consecutive plants. Record percent infested and color(s) of mold. Repeat 10 times in a 25 acre field, including representative areas.

Sampling For Corn Nematodes

A nematode assay can be valuable to: 1) confirm a suspected nematode problem or 2) eliminate nematodes as one of several possible causes of poor plant growth.

The best results are obtained when soil and root samples are taken 6 to 10 weeks after planting. Nematode populations at this time appear to correlate best with grain yield. However, late summer or fall samples can also be useful in predicting next year's problems.

Nematode damage to corn often appears in circular or oval pockets in the field. Rarely does an entire field show symptoms. Sample the suspected areas.

There are several ways to take a soil sample for nematode analysis. The following is a general guide.

1. Use a soil probe, narrow-blade trowel or a shovel. Take samples close to plants and to a depth of 8 to 10 inches. Discard the upper 2 inches of soil, especially if it is dry. Be sure to include plant roots.
2. One sample is adequate per 10 acre field or suspected area within the field. Sample soil and roots from 10 plants and mix into one composite sample - 2 pints of soil is adequate. Sample from plants in the margins of suspected areas and not from their centers.
3. Place samples in sturdy plastic bags. Fasten the open end securely and accurately label samples. Keep the samples from becoming overheated. Mail samples early in the week to avoid delays in transit.

Corn Insect Scouting

Scouting methods for insects vary according to species present. The following are scouting guidelines for the major insect pests of Wisconsin field corn.

Seed Corn Maggot and Seed Corn Beetles

Scheduled scouting for seed corn maggots and seed corn beetle damage is unnecessary. However, if you find wilted, yellowed or stunted plants during seedling stand counts, or during cutworm or other soil insect scouting activities, check for damage from these insects. If numbers justify it, check 50 plants in 5 randomly selected areas of the field (250 plants) to determine percent damaged plants. Dig up and examine damaged seedlings and search for seeds in areas that have no plants to determine if skips are insect or planter related. Unlike the spotty nature of wireworm damage, damage from these insects will usually cover most of the field.

Wireworms

Like seed corn maggot and seed corn beetles, scheduled scouting for wireworms is not suggested. However, symptoms of their activity may be observed during seedling stand counts or cutworm scouting. If wireworm damage is suspected, check 50 plants in 5 areas of the field to determine average percent of plants damaged. Dig up several damaged plants along with a 4-6 inch core of surrounding soil. Check for wireworms in the soil surrounding the roots, the underground portion of the stem, and in the remains of the seeds (if still present). Search for seeds in areas where plants are missing.

White Grubs

Routine scouting is not suggested. However, damage may be observed during seedling stand counts or cutworm surveys. If signs of white grub damage are found, make counts on 25 plants in 5 areas of the field to determine percentage of damaged plants. Dig up suspect plants and examine the roots for signs of pruning; search for grubs in the soil immediately surrounding the root zone. Record the percent of damaged plants and number of grubs found.

Stalk Borer and Hop-Vine Borer

Start scouting for plant damage at emergence and until approximately mid-June. Examine 5 sets of 50 consecutive plants for signs of damage and record the percent of plants damaged by each species. Infestations will typically be found in the first 4-6 rows around field margins, grassy waterways, and alfalfa/grass strips. However, damage can be found field-wide if grassy weeds were present the previous year. If the infestation is localized, make detailed maps of infested areas so spot treatments can be made.

Cutworms

As corn plants emerge, check 5 groups of 50 plants. Cutworm infestations are already started by the time corn is planted. Low, wet fields or low, wet areas within fields have a greater probability of attack from black cutworms. Reduced tillage, weed growth prior to tillage, and late planting are also suspected of contributing to cutworm problems. Some Wisconsin farmers have experienced severe cutworm damage in first year corn following spring plowed sod or alfalfa/grass sod.

Check for cutworms on and below the soil surface adjacent to damaged plants. Occasionally cutworms will be found under crop residue, soil clods, or in soil cracks. Count and record the number of damaged plants (leaf feeding, cut, or wilting), the number and size of cutworms and crop stage.

Corn Leaf Aphid

Examine 10 sets of 5 consecutive plants for corn leaf aphids during the late whorl to early tassel emergence stages. The aphids initially will be found in the whorl of younger plants and later on the tassel. Start scouting for aphids just prior to or during the tassel emergence period. You will, of course, have to pull the whorl leaves, unroll them, and search for aphids.

Because parasites, predators, and diseases will often keep aphids under control, it is important to note and record their presence. Look for lady beetles and lady beetle larvae, lacewing larvae (aphid lions) and syrphid fly maggots. The aphid colonies may have brown or golden aphids; these are diseased or parasitized.

Corn Rootworms

Make three counts of both species of beetles at 7-10 day intervals between mid-July and Sept. 1. Count the total number of western and northern rootworm beetles on 50 plants (10 sets of 5 plants) each time. Do not select adjacent plants at each location;

approach plants with caution because the beetles are easily disturbed. Leave a space of about 3-4 plants between each sampled plant.

Count the beetles on the entire plant, including the ear tip, the tassel, the leaf surfaces and behind leaf axils. When approaching a plant, grasp the ear tip firmly with one hand while you use the other to search for beetles on the rest of the plant. When you are ready to examine the silks and ear tip for beetles, open your hand carefully so none of the beetles escape unnoticed. Expose the ear tip as some beetles may be feeding on developing kernels.

The purpose of this scouting is twofold. First, accurate counts are necessary to determine if the silks need insecticide protection against beetle feeding. Because of this, one of the counts must be made at the onset of silking. The second purpose is to determine the potential for rootworm larval damage to corn planted the following year in the field.

European Corn Borer

First Generation. Scouting activity for first generation European corn borer must begin at 700 borer degree days (base 50 degrees Fahrenheit). In southern Wisconsin, this can occur as early as the first week of June .

Examine 10 random sets of 10-20 consecutive plants each. Record the number of plants that show signs of whorl feeding. Dissect one infested plant per set and record the number of larvae found on the leaves or in the whorl. The usual range is 1-5 larvae per plant. More mature larvae (3/8 inch or larger) will be found within the stalk and are no longer susceptible to chemical insecticide treatments. These mature larvae should not be included in the larval counts.

Larvae are susceptible to chemical control for only 7-10 days after eggs hatch depending on temperatures. It is important that scouting visits are timely to make sure that larvae are not feeding within the stalk.

Second Generation Scouting. Egg scouting is necessary after tassels emerge; leaf-feeding is no longer a valid indicator once tassels emerge. Begin to look for second generation borer eggs at 1250 borer degree days (mid to late-July in southern Wisconsin). Examine 10 random sets of 5 consecutive plants each. Egg masses are usually laid on the undersides of leaves. Examine the undersides of all leaves for unhatched masses or the remains of hatched masses. Record the number of egg masses found. When an egg mass is found, record the egg's stage of development according to the following categories:

White (W) - eggs are newly laid
Cream (C) - intermediate
Black head (B) - will hatch in a few hours
Hatched (H) - remains of an egg mass

Special Problems

When monitoring corn there will be situations when scouts encounter crop injury from unknown causes. When this occurs, it is very important that scouts collect suitable plant samples and gather enough background information to make proper identification possible. Collect a variety of plant samples (including roots) to show a variety of symptoms. Include healthy plants from the same field so comparisons can be made. All samples should be stored in a cooler until the scout has access to a refrigerator. Label each sample with the grower's name, field number and gather as much field history data as possible. Information such as variety, planting date, environmental conditions, pesticide use information (for the field in question as well as surrounding fields), soil type, distribution of symptoms in the field, cropping history, and soil test results are invaluable for making proper diagnosis. Scouts should also carry plastic vials with them in case unknown insects are found. Store the insect samples in a cooler until identification can be made.

References

Whether you are scouting your own fields or someone else's, you are sure to have many questions. Your local county extension agent can serve as an excellent source of information.
The following is a list of suggested reading materials that are available from your local county extension office or from:

Extension Publications
630 West Mifflin Street, Room 170
Madison, WI 53703
Phone (608) 262-3346

- Weeds of the North Central States, North Central Regional Publication (NCR) # 281
- Annual Broadleaf Weed Seedling Identification, NCR # 89
- Herbicide Mode of Action and Injry Symptoms, NCR #377
- A3595, A Simple Method for Predicting Future Weed Problems
- A3615, Avoiding Herbicide Resistance in Weeds
- A2296, Field Crop Herbicide Manual
- Wild Proso Millet Control in Field Crops, NCR # 265
- Controlling Canada Thistle in Field Crops, NCR # 218
- Yellow nutsedge Control in Field Crops, NCR # 220
- Quackgrass Control in Field Crops, NCR # 219
- A 1684, Corn Pest Management in Wisconsin
- A 2994, Nematodes and the Damage They Can Cause
- A 3175, Eyespot of Corn
- A 7800603, Corn Diseases I
- A 7800604, Corn Diseases II
- A 2046, Corn Insects Above Ground
- A 2047, Corn Insects Below Ground
- A 3328, Corn Rootworms
- A3631, Corn Rootworm Pest ID card
- A 1220, The European Corn Borer
- A 3327, The Armyworm
- A 3354, Stalk-Boring Insect Pests of Corn
- Special Report No. 48, How a Corn Plant Develops.

Newsletters

For updates on crop and pest related topics, the following newsletters are suggested. Each is published on a weekly schedule during the growing season.

Wisconsin Crop Manager
Department of Agronomy
1575 Linden Drive
Madison, WI 53706-1597

Wisconsin Cooperative Pest Survey Bulletin
Bureau of Plant Industry
P.O. Bow 8911
Madison, WI 53708-8911

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Produced by Integrated Pest Management and Nutrient and Pest Management (NPM) programs, University of Wisconsin-Extension.

Appendix A: Field History (example)

Grower Information

Grower

Address

Town

Zip

County

Business Phone

Home Phone

Field Location

Township

Section

Field Number

Acres

Field Specifics

Slope (degree and direction)

Drainage

Soil Type(s)

Irrigated or Dryland?

Percent Organic Matter

Field Map

Crop Information

	Variety	Planting Date	Planting Rage	Final Population	Harvest Date(s)	Yield
1st crop						
2nd crop						
3rd crop						
Other comments						

Nutrients

Manure	Date	Load Size	# of Loads	Incorporated?	Type of manure	Temperature

Lime T/A	Date	T/A	Cost	Source of Purchase

Fertilizer	Date	Analysis	Cost	Rate	Source of Purchase
Broadcast Fertilizer					
Starter Fertilizer					
Side Dress Fertilizer					
Other Fertilizer					

Herbicide*

Materials Used

Date(s)

Rate

Application Method

Weather /Rain / Temperature

Weed Problems

Insecticide

Materials Used

Date(s)

Rate

Application Method

Weather /Rain / Temperature

Insect Problems

Equipment

Tillage	Date	Equipment Size	Time Spent
Primary			
Secondary			
Planting			
Cultivation			
Harvesting (type)			
Other			

Soil Tests

Routine	OM	pH	N	P	K	S

Micro’s

Nitrate Test

Tissue Test	N	P	K	S	B	Zn

Major Soil Type

Miscellaneous

Fungicides

Seed Treatment

Foliar Treatment

Crop Insurance

Crop Scouting

Dates

Appendix B: Sweet Corn Pest Management (early season)

General Info.

Farmer's name :	Date :	Time : am pm	County :	Field No./ Location :
Crop stage :	Weed height :	Corn borer degree days (Base 50 ^{0}) :		Scout's name :

Field Map

Weeds

Herbicide program: PPI Pre Post Date applied:	Date of 1st rainfall of 1/2 or more after herbicide application :

Plant population

Count plants in 20 ft. at 5 locations. Circle row width. A = row width factors: 30"=174, 36"=145, 38"=138, 40"=131

	1	2	3	4	5	T	
No. of plants							x A = __________ plants per acre

Notes

(diseases, abnormal plants, other insects of importance, etc.)

Cutworms

Sample 50 consecutive plants/set, count worms around all cut plants/set, record predominate instar present.

	1	2	3	4	5	T	
Damaged plants/set							÷ 2.5 = _______% damage
Number of insects							÷ 2.5 = _______% damage
Predominant instar							Instar range ___________

European Corn Borer

1st generation : Sample 10 consecutive plants/set. In each set, count the number of insects on 2 infested plants per set. Instar range I-V.

	1	2	3	4	5	6	7	8	9	10	T	
Damaged plants/set												_________% of plants with whorl feeding
Number of insects												T/20 = ______ ave. # of larvae / plant
Predominant instar												Instar range ___________
Extended leaf height (10 plants) __________ inches												

Corn Leaf Aphid

Each set consists of 5 consecutive plants. Note beneficial insects.

	1	2	3	4	5	6	7	8	9	10	T	
None-few present (< 50 aphids/plant)												x 2.0 = _______% low
Moderate-high (> 50 aphids/plant)												x 2.0 = _______% mod-high
Tassel covered												x 2.0 = _______% tassel covered

Appendix C: Sweet Corn Pest Management (late season)

General Info.

Farmer's name :	Date :	Time : am pm	County :	Field No./ Location :
Crop stage :	Corn borer degree days (Base 50 ^{0}) :		Scout's name :	

European Corn Borer

2nd generation : Examine 5 consecutive plants/set for egg masses.

	1	2	3	4	5	6	7	8	9	10	T
White stage											
Cream stage											
Black head stage											
Hatched											
Total divided by 50 = Average egg masses per plant											

Corn Rootwom Beetles

Examine 5 plants/set. Do not chose adjacent plants.

	1	2	3	4	5	6	7	8	9	10	T
Northern corn rootworm											
Western corn rootworm											
Total divided by 50 = Average beetles per plant											

Trap Results

Pheromone Traps:

Location(s):

Date / # caught :

Blacklight Traps:

Fall Armyworm

European Corn Borer

Corn Earworm

Field Map

Field Notes

Appendix D: Weed Map

General Info.

Farmer's name :			Date :	Crop :
Field No./ :	Section :	County :		

Date of Application _______ / ______ / ______
Month Day Year

Restricted-Use Pesticide ☐

PESTICIDE APPLICATION RECORD

This form meets ALL federal and Wisconsin pesticide application recordkeeping requirements.

Applicator

Name ______________________ Business Phone (____) ______________

Certification No. ______________ (Exp. Date ___ / ___ / ___) License No. ______________

Address ______________________
Route or Street

______________________ ______________ ______________
City State Zip

Client

Name ______________________ Business Phone (____) ______________

Address ______________________
Route or Street

______________________ ______________ ______________
City State Zip

Treated Site

Location ______________________

Specific Crop/Commodity/Structure/Livestock/Other ______________________

Size/Number ______________ Target Pest(s) ______________________

Pesticide Product(s) Used

Trade Name ______________ Manufacturer (optional) ______________
EPA Reg. No. ______________ Active Ingredient (optional) ______________

Trade Name ______________ Manufacturer (optional) ______________
EPA Reg. No. ______________ Active Ingredient (optional) ______________

Trade Name ______________ Manufacturer (optional) ______________
EPA Reg. No. ______________ Active Ingredient (optional) ______________

Application Information

Time ____ : ____ AM/PM to ____ : ____ AM/PM Mixing/Loading Location ______________

Application Rate(s) ______________________

Total Amount of Each Product Used ______________________

If you apply a soil fumigant that contains metam sodium, record the following additional information:

Soil Temperature at Depth of 5 to 6 Inches (if you used knife rig injection or chemigation) ______________

Time of 1st Inspection ____ : ____ AM/PM Results/Action Taken ______________

Time of 2nd Inspection ____ : ____ AM/PM Results/Action Taken ______________

Comments (optional): Put additional comments (weather, site conditions, pest population, etc.) on back.

How to Use the Pesticide Application Record Form

Fill out the relevant sections of this form on the day that you apply any pesticide. Keep the form on file for at least 2 years (3 years if you apply an atrazine-containing product) to comply with all current federal and Wisconsin recordkeeping requirements.

Restricted-Use Pesticide. Put an 'X' in the box in the upper right hand corner of the form if you applied a restricted-use pesticide. This will make it easier to retrieve records of such applications for the USDA if you are requested to do so.

Applicator. To save time, fill out the applicator information before you make photocopies of the form. Write 'NA' (for 'not applicable') on the appropriate line(s) if you are not certified and/or licensed.

Client. Fill out this part of the form if you are a commercial applicator or if you are a private applicator making an application on another person's land, even if only for exchange of services.

Treated Site.

Location. Provide enough information that would allow someone to find the way to the location of the application. For example, if you use a field-numbering system, enter the field number on the form but also have a copy of the farm plan on file where you keep your pesticide records; that way, a person could look at the farm plan and determine how to get to the field in question.

Specific Crop/Commodity/Structure/Livestock/Other. This is the site to which you applied the pesticide. Be specific enough to accurately describe what was treated. For example, 'field corn' vs. 'sweet corn' vs. 'field corn seed' vs. 'stored corn.' Likewise, if you treat a storage structure, such as a grain bin or potato warehouse, be sure to mention whether or not it was empty at the time of treatment. Other examples of sites include dairy cows, chickens, fence rows, barns, and private ponds.

Size/Number. Generally speaking, use whatever units of measurement are mentioned on the label. Examples include acres, feet of row, cubic feet, and number of livestock.

Target Pest(s). Be as specific as you can be; this will help you determine how effective the application was. For commercial applicators, it is especially important that your client know which pests the treatment was intended to control.

Pesticide(s) Used. You can get the requested information from the product label. If you tank mix 2 or more pesticide products, record each product separately. If you use a restricted-use pesticide, even in a tank mix with nonrestricted-use pesticides, put an 'X' in the box in the upper right-hand corner of the form.

Active Ingredient(s) *optional*. Record the common name of the active ingredient that appears in the ingredients statement. (Do not record the complex chemical name that may also appear in parentheses after the common name.) If a product contains more than 1 active ingredient (as is the case with all prepackaged tank mixes), record the common name of each active ingredient.

Application Information. The application rate is just your calibrated rate (pints or pounds of product per acre, percent solution, etc.) Also record the spray volume applied per acre (or the spray volume used to treat a barn, fence row, etc.) If you apply a tank mix, be sure to record the application rate and the total amount of product used for each product in the mix. The mixing/loading location is where you loaded the pesticide into the application equipment or nurse tank. To record this location, use the same guidelines described above for the location of the treated site; you can write 'site of application' if that was the mixing/loading location as well.

Comments. Although not required by law, additional comments can help you evaluate the effectiveness of the pesticide application. Examples include weather conditions, application equipment, adjuvants, and timing of application (e.g., preplant incorporated or postemergence). Because you will use a separate, photocopied recordkeeping form for each application, you can record optional comments on the blank back of the photocopied form.

Date of Application _______ / _______ / _______
Month Day Year

Restricted-Use Pesticide ☐

PESTICIDE APPLICATION RECORD

This form meets ALL federal and Wisconsin pesticide application recordkeeping requirements.

Applicator

Name ______________________ Business Phone (____) ____________

Certification No. ______________ (Exp. Date___ /___ /___) License No. ____________

Address ______________________________
Route or Street

______________ ______ ______
City State Zip

Client

Name ______________________ Business Phone (____) ____________

Address ______________________________
Route or Street

______________ ______ ______
City State Zip

Treated Site

Location ______________________________

Specific Crop/Commodity/Structure/Livestock/Other ______________

Size/Number ______________ Target Pest(s) ______________

Pesticide Product(s) Used

Trade Name ______________ Manufacturer (optional) ______________
EPA Reg. No. ______________ Active Ingredient (optional) ______________

Trade Name ______________ Manufacturer (optional) ______________
EPA Reg. No. ______________ Active Ingredient (optional) ______________

Trade Name ______________ Manufacturer (optional) ______________
EPA Reg. No. ______________ Active Ingredient (optional) ______________

Application Information

Time ____ : ____ AM/PM to ____ : ____ AM/PM Mixing/Loading Location ______________

Application Rate(s)

Total Amount of Each Product Used ______________

If you apply a soil fumigant that contains metam sodium, record the following additional information:

Soil Temperature at Depth of 5 to 6 Inches (if you used knife rig injection or chemigation) ____________

Time of 1st Inspection ____ : ____ AM/PM Results/Action Taken ______________

Time of 2nd Inspection ____ : ____ AM/PM Results/Action Taken ______________

Comments (optional): Put additional comments (weather, site conditions, pest population, etc.) on back.

PAT Pesticide Applicator Training
University of Wisconsin Extension

March 1994

How to Use the Pesticide Application Record Form

Fill out the relevant sections of this form on the day that you apply any pesticide. Keep the form on file for at least 2 years (3 years if you apply an atrazine-containing product) to comply with all current federal and Wisconsin recordkeeping requirements.

Restricted-Use Pesticide. Put an 'X' in the box in the upper right hand corner of the form if you applied a restricted-use pesticide. This will make it easier to retrieve records of such applications for the USDA if you are requested to do so.

Applicator. To save time, fill out the applicator information before you make photocopies of the form. Write 'NA' (for 'not applicable') on the appropriate line(s) if you are not certified and/or licensed.

Client. Fill out this part of the form if you are a commercial applicator or if you are a private applicator making an application on another person's land, even if only for exchange of services.

Treated Site.

Location. Provide enough information that would allow someone to find the way to the location of the application. For example, if you use a field-numbering system, enter the field number on the form but also have a copy of the farm plan on file where you keep your pesticide records; that way, a person could look at the farm plan and determine how to get to the field in question.

Specific Crop/Commodity/Structure/Livestock/Other. This is the site to which you applied the pesticide. Be specific enough to accurately describe what was treated. For example, 'field corn' vs. 'sweet corn' vs. 'field corn seed' vs. 'stored corn.' Likewise, if you treat a storage structure, such as a grain bin or potato warehouse, be sure to mention whether or not it was empty at the time of treatment. Other examples of sites include dairy cows, chickens, fence rows, barns, and private ponds.

Size/Number. Generally speaking, use whatever units of measurement are mentioned on the label. Examples include acres, feet of row, cubic feet, and number of livestock.

Target Pest(s). Be as specific as you can be; this will help you determine how effective the application was. For commercial applicators, it is especially important that your client know which pests the treatment was intended to control.

Pesticide(s) Used. You can get the requested information from the product label. If you tank mix 2 or more pesticide products, record each product separately. If you use a restricted-use pesticide, even in a tank mix with nonrestricted-use pesticides, put an 'X' in the box in the upper right-hand corner of the form.

Active Ingredient(s) *optional*. Record the common name of the active ingredient that appears in the ingredients statement. (Do not record the complex chemical name that may also appear in parentheses after the common name.) If a product contains more than 1 active ingredient (as is the case with all prepackaged tank mixes), record the common name of each active ingredient.

Application Information. The application rate is just your calibrated rate (pints or pounds of product per acre, percent solution, etc.) Also record the spray volume applied per acre (or the spray volume used to treat a barn, fence row, etc.) If you apply a tank mix, be sure to record the application rate and the total amount of product used for each product in the mix. The mixing/loading location is where you loaded the pesticide into the application equipment or nurse tank. To record this location, use the same guidelines described above for the location of the treated site; you can write 'site of application' if that was the mixing/loading location as well.

Comments. Although not required by law, additional comments can help you evaluate the effectiveness of the pesticide application. Examples include weather conditions, application equipment, adjuvants, and timing of application
(e.g., preplant incorporated or postemergence). Because you will use a separate, photocopied recordkeeping form for each application, you can record optional comments on the blank back of the photocopied form.

Armyworm

Scientific Name: *Pseudaletia unipunctata*
Order: Lepidoptera
Family: Noctuidae

General Information

Biological Description

The armyworm can be a serious problem on field & sweet corn; it prefers to feed on grasses and grains. Outbreaks are more severe following cold, wet, spring weather. The sand-colored moths have a wing span of 1.5" with definitive white dots in the center of each forewing and dark markings on the hind wings. The brownish-green larvae are hairless, have alternate dark and light stripes down their backs and are about 2" long when fully grown. The head is pale brown with dark markings. Pupae are dark brown and approximately 3/4 inch in length. They are sharply tapered at the tail end with a much more rounded head end. The greenish white eggs are laid in rows or clusters on leaves. Moths often seem to congregate in certain locations. Armyworms often are confused with the variegated cutworm and other related species.

Economic Importance

Damage is sporadic and dependent on heavy flights of southern moths reaching Wisconsin. Armyworms may be a problem is sweetcorn follows soybeans.

Life Cycle

It is not known if the armyworm overwinters in Wisconsin. The moths usually appear in late April and early May. Most of the early season moths are immigrants from southern states. Once they arrive, they immediately mate. Eggs are laid in the evening and at night and eggs are laid in rows or clumps of many eggs. Grasses and small grains are the preferred host and blades are often folded and sealed to protect the eggs. One week to 10 days after the eggs are laid, the larvae emerge and begin to feed. After feeding for 3-4 weeks, the full-grown larvae pupate for an additional 2 weeks and emerge as adults. There are 3 generations per season, with each generation lasting 5-6 weeks. The first generation is small and does little damage, however the success of this generation produces later, more injurious, generations of armyworms. The second larval generation, which appears in July, is the largest and most damaging generation to Wisconsin crops. The fall generation is typically not injurious and is often heavily parasitized by beneficial insects, fungi and viruses.

Host Range

Armyworms attack all grasses, particularly wheat, oats, corn barley and rye and some legumes; but when under stress armyworms will attack neighboring vegetable crops and seedling alfalfa. Additionally, the presence of grass weeds in vegetable fields will attract moths for egg laying.

Environmental Factors

Cold, wet spring weather precipitates armyworm outbreaks.

Damage/Symptoms

Larvae tend to feed at night or on cloudy days and hide in the soil or under foliage during the day. There are two types of infestations that can occur in sweet corn. Infestations may occur throughout a corn field in July if grassy weeds such as foxtail, quackgrass, goosegrass, and nutsedge are present for oviposition in the field. In this case, plants in scattered areas of the field will have ragged leaves from larval feeding. The other type of infestation results when armyworms migrate from pastures, oats, or grassy pea or alfalfa fields, to destroy the outside rows of corn. Damage is usually highest along the field edge or in grassy spots.

Scouting Procedure and ET

Timely detection is critical if post-emergent insecticidal treatment is to be effective. If you find signs of armyworm feeding, check 5 sets of 20 plants at random. Record the number of damaged plants and the number of worms per plant. Repeat in several locations within the field since infestations may be restricted to certain areas. Damage usually begins along field edges and moves inward as the insects migrate. Spot treat if possible when there are two or more armyworms at 3/4 inch or longer per plant on 25% of the plants OR there is one armyworm per plant on 75% of the plants. When armyworms migrate from adjoining areas, treat only border rows.

Integrated Control

Non-Chemical Control

Natural Control A number of braconid wasps and tachinid flies help keep armyworm numbers down, as do birds, toads, skunks and some domestic fowl. Armyworms are only problematic in grassy areas.

Cultural Control Since female moths prefer to lay eggs in grassy areas, keeping grassy weeds controlled will lessen the possibility of problems. Avoid planting susceptible crops in low wet areas or in rotations following sod. If this is unavoidable, be sure to plow in the fall of the previous season to decrease early spring egg-laying sites. Killing grass with a herbicide or tillage may drive armyworms to the susceptible vegetables.

Biological Control : Several natural enemies exist which may keep armyworm populations low. The red-tailed tachinid fly (Winthemia quadripustulata) is one such biocontrol agent. It lays its eggs on the armyworm's back and the tachinid larvae bore into larval armyworms to feed. In addition, several ground beetles and parasitic hymenoptera prey upon the armyworm. There is also and egg parasite (Telenomus minimus) that is effective in preventing egg hatch and subsequent larval feeding damage.

Chemical Control

Commercial : Carbaryl, chlorpyrifos, esfenvalerate, methomyl, micro-encapsulated methyl parathion, and permethrin are foliar treatments which are labeled for the control of armyworms in sweet corn. Refer to the product label for specific application instructions and precautions.

Homeowner: Apply carbaryl bait if extensive foliage feeding observed.

Insecticide Resistance: None.

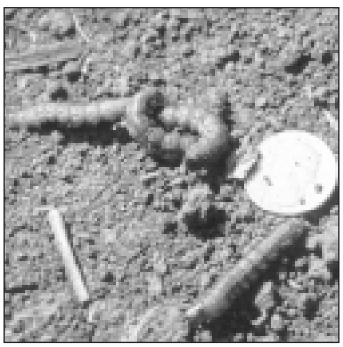
References

R. H. Davidson and W. F. Lyon (1987) Insect Pests 8th Ed. of Farm, Garden, and Home. John Wiley & Sons, New York 640 pp.

C. L. Metcalf and R L. Metcalf (1993) Destructive and Useful Insects, Their Habits and Control 5th Ed. McGraw-Hill Book Co., New York.

Black Cutworm

Scientific Name: *Agrotis ipsilon*
Order: Lepidoptera
Family: Noctuidae.



General Information

Biological Description

Black cutworm larvae generally feed at, or below the ground surface at night. It is an active feeder on young foliage or stem tissue and will cut off many young seedlings in an evening. The large, greasy, dark gray larvae will curl up into a tight c-shape if disturbed. Mature, 6th instar larvae, are 1.5" long and have a grainy texture. Adult cutworms are gray moths which have a series of distinctive dark markings on their forewings and lighter colored hind wings. The black cutworm larvae are easily confused with other cutworms, but generally damage crops earlier in the season than other species. This cutworm is particularly problematic to the home gardener.

Economic Importance

Damage is not common on sweet corn but heavy infestation can decimate stands so severely that replanting may be necessary.

Life Cycle

Moths that appear in late May have migrated into Wisconsin from other states. Overwintering black cutworms in Wisconsin are rarely abundant enough to cause significant damage. Female moths lay hundreds of eggs either singly or in clusters. Oviposition is typically concentrated on low-growing vegetation such as chickweed, curly dock, mustards or plant residue from the previous year's crop. Corn planted after soybeans is often a preferred oviposition site. As a result, heavy spring weed growth, newly broken sod, previous crop and plant debris all increase the risk of black cutworm infestations. Late-planted cornfields are most heavily damaged during an outbreak of black cutworms. Generally, black cutworm moths will not lay eggs in fields that have already been planted. Young larvae (less than one-half inch in length) feed above ground. Larger larvae feed at, or just below the soil surface, although in fields with very dry soil conditions the larvae may be found 2-3 inches deep. Cutting stage larvae may take as long as 34 days to pupate at temperatures of 60°F, while only 12 days may be required at temperatures of 75°F. There are three generations per year. It is the first generation which is active during May and June that causes the most damage.

Host Range

Black cutworm larvae attack a wide variety of vegetable and field crops, especially in the seedling stage.

Environmental Factors

Excessive rainfall may disrupt egg-laying. Flooding may force larvae to the soil surface during the day where they are attacked by parasites or predators.

Damage/Symptoms

Newly hatched larvae are unable to chew entirely through the leaf surface resulting in a "window pane" appearance on the leaves. As the larvae grow their feeding damage becomes pinholes in the leaves and often, complete defoliation of the leaves. Once the larvae reach the "cutting" stage, they are 1/2 inch long and cut the stem at, or just below the soil surface. This type of injury is common during extended periods of dry weather. In later crop stages (V3-V4) large larvae may not be able to cut plants. Instead, larvae will burrow into the corn plant, below ground level, and result in symptoms often called "wilted whorl" or "dead heart". In these situations, the newly emerging leave wilt. Older leaves may remain green for a period of time.

Scouting Procedure and ET

Timely detection is critical if post-emergence insecticidal treatment is to be effective. Pheromone traps are useful for monitoring moth activity but do not correlate well with predictions of whether damage will occur as well as when or where damage may be expected. Concerns over damage are greatest during the first ten days to two weeks after corn emergence.

Integrated Control

Non-Chemical Control

Natural Control: A number of braconid parasites and predaceous ground beetles help keep cutworm numbers down. Cutworms are most problematic in low, wet, grassy areas. Cutworms serve as prey to birds.

Cultural Control: Since female moths prefer to lay eggs in weedy situations, keeping weeds controlled will lessen the possibility of problems. Avoid planting susceptible crops in low wet areas or in rotations following sod. Coffee cans or other cylindrical barriers will protect small plantings from damage.

Biological Control : Several species of tachinids, braconids and ichneumonids help reduce populations.

Chemical Control

Commercial : Broadcast applications of permethrin or chlorpyrifos are recommended for managing black cutworms. Refer to the product label for more information on specific application instructions and precautions

Homeowner: Apply Sevin bait if extensive foliage feeding observed.

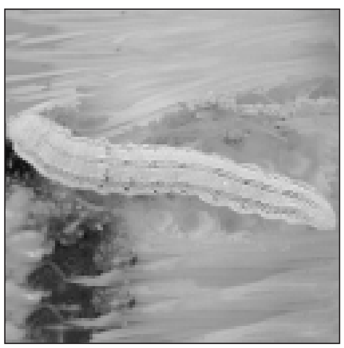
Insecticide Resistance: None.

References

R. H. Davidson and W. F. Lyon (1987) Insect Pests 8th Ed. of Farm, Garden, and Home. John Wiley & Sons, New York 640 pp.

Corn Earworm

Scientific Name: *Helicoverpa zea* (Boddie)
Order: Lepidoptera
Common Name: Tomato Fruitworm



General Information

Biological Description

Adult corn earworms are grayish brown moths with a wing span of about 1.5". The front wings are marked with dark-gray irregular lines and with a dark area near the wing tip. The hind wings are white with dark spots or areas along the margins. The olive-brown larvae generally have 3 or 4 dark stripes along their back and measure 2" long when mature. The head is yellow and not spotted. The 1/32" yellowish, sculptured, hemispherical eggs are laid singly on the foliage or corn silks.

Economic Importance

Corn earworm is of greatest concern in very early or very late planted corn, and requires extensive spraying during some years. Its effect or yield is minimal but its damage leads to rejection of the ears by consumers and contamination of processed corn. Processing sweet corn planted for harvest in late September to early October requires the greatest protection.

Life Cycle

Few corn earworms overwinter in Wisconsin, most migrate annually from the South into the state, reinfesting sweet corn fields, vegetable crops and a wide range of field crops. Corn earworms mainly overwinter in the south as pupa buried in the soil. Pupae complete development in the spring. Adults emerge in early May and begin their northward migration. The moths fly mainly at dusk or during warm cloudy days. Eggs are laid individually on fresh corn silks. Each fertilized female can deposit up to 1000 eggs during her lifetime. Larvae emerging from the eggs immediately crawl into the silk channels at the ear tip and begin feeding. During the entire larval stage, earworms move very little and feeding is confined to the ear tip. After approximately two weeks, the larvae drop to the ground to pupate. Approximately two weeks later, adult moths emerge and work their way to the soil surface. Development from egg to adult requires about 30 days in midsummer. In the North, there are 2 generations per year. In Wisconsin, first generation adults usually appear in late June. The more damaging second generation appears in late August to early September. The small early summer generation generally does little damage.

Host Range

Sweet corn, tomatoes, lettuce, peppers, and beans all serve as hosts to the corn earworm.

Damage/Symptoms

Fresh market sweet corn is most susceptible to early season damage. Damage to sweet corn does not reduce yields significantly since even severe attacks result in less than 10% damage to the kernels. The primary consequence of damage is consumer rejection. Damage to corn results when the larvae feed in the tips of the ears, devouring kernels and contaminating the ear.

Scouting Procedure and ET

Treat if 3 adults/black light trap are caught on 2-3 consecutive nights or if 5-10 moths are caught per pheromone trap. Treat during the peak adult generation flights.

Integrated Control

Non-Chemical Control

Natural Control: Larvae are cannibalistic and therefore only one larva is usually found per fruit or ear. The eggs are parasitized by Trichograma wasps, and preyed upon by the flower bug, Orius tristicolor. Larvae are parasitized by a number of chalcid, braconid wasps and virus.

Cultural Control: Varieties with long and narrow silk channels in crease the level of cannibalism among larvae.

Chemical Control

Commercial: Esfenvalerate, methomyl and permethrin are registered for the control of corn earworm in commercial sweet corn fields. Insecticide applications should be made as soon as silks appear. Two to five applications may be necessary at 4-5 day intervals. Once the silks start to wilt and dry, they rapidly lose their attractiveness to moths.

Homeowner: Treat sweet corn with Sevin at 4-5 day intervals when silks begin to appear and continue application until the silks start to dry.

Insecticide Resistance: None.

References

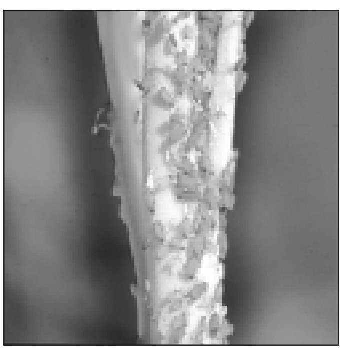
R. H. Davidson and W. F. Lyon (1979) Insect Pests 7th Ed. of Farm, Garden, and Home. John Wiley & Sons, New York 596 pp.

K. F. Harris and K. Maramorosch, Eds. (1980) Vectors of Plant Pathogens. Academic Press, New York. 467 pp.

C. L. Metcalf and R. L. Metcalf (1993) Destructive and Useful Insects, their Habits and Control 5th Ed. McGraw-Hill Book Co., New York 1087 pp.

Corn Leaf Aphid

Scientific Name: *Rhopalosiphum maidis*
Order: Homoptera
Family: Aphididae



General Information

Biological Description

The corn leaf aphid is a small, bluish-green to gray, soft-bodied insect about the size of a pinhead. They may be winged or wingless. One unique characteristic of aphids is the ability of the adult females to give birth to live young as opposed to laying eggs like other insects. Both the immature nymphs and adults appear similar and it is often difficult to distinguish between the two.

Economic Importance

The corn leaf aphid may be a problem in sweet corn in Wisconsin later in the season. This insect is particularly important because it is suspected to be a vector for the maize dwarf mosaic virus although this hasn't been proven.

Life Cycle

Corn leaf aphids appear in the upper Midwest in mid-summer as winged forms migrate from the south. There may be as many as nine generations per year. Winged and wingless adults as well as nymphs may be found on the same plant at the same time. As the aphids grow, they shed their skins. In heavy infestations, plants may take on a grayish cast as these skins begin to accumulate. Because the aphid's diet is high in sugars, the honey dew excreted by the aphid as waste serves as an excellent medium for the growth of molds. These molds may give the plant a black appearance.

Host Range

The corn leaf aphid may be found on all varieties of corn as well as many other wild and cultivated plants in the grass family.

Environmental Factors:

Heavy rain can rapidly decrease aphid populations as well as produce ideal conditions for the rapid spread of several fungal diseases.

Damage/Symptoms

Like other aphids, the corn leaf aphid possesses fine, needle-like, piercing mouthparts which are inserted between plant cells and into the vascular tissue. Typically, this causes little direct morphological damage. Under heavy infestations, leaves may curl, wilt and become chlorotic. Plants may become sticky with honey dew or blackened with sooty mold, a fungus which grows saprophytically on the honey dew. Occasionally, heavily infested plants may be barren if aphid feeding on the tassel or silk interferes with pollination. Corn leaf aphids may be vectors for some diseases, although this hasn't been proven. Large amounts of honeydew may attract corn earworm moths.

Scouting Procedure and ET

Corn leaf aphids can be found in the curl of the leaves, deep within the whorl, the upper part of the corn stalk, and the unemerged tassel and emerged tassel. Examine 10 sets of five consecutive plants (50 plants) for corn leaf aphids during the late whorl to early tassel emergence stages. You will, of course, have to pull the whorl leaves, unroll them, and search for the aphids. If 50% of the plants have 50 or more aphid, make a single insecticide application before tassels have emerged but not before upper whorl leaves open to expose tassels.

Integrated Control

Non-Chemical Control

Natural Control: Several parasites, predators, and pathogens are effective in keeping aphid populations below economically damaging levels. When scouting, look for lady beetle adults and larvae, lacewing larvae and syrphid fly maggots. Aphid colonies with brown or golden aphids are diseased or parasitized.

Cultural Control: Damage by the aphids may be avoided by planting early in the season. Proper tillage and fertilization which hastens plant growth is also recommended.

Biological Control: None.

Chemical Control

Commercial: Chlorpyrifos, esfenvalerate, and micro-encapsulated methyl parathion are labeled for the control of corn leaf aphids. Make a single application of insecticide before tassels have emerged but not before the upper whorl leaves open to expose tassels. Refer to the product label for more information on specific application instructions and precautions.

Homeowner: Early planting of sweet corn is recommended to avoid problems with the corn leaf aphid.

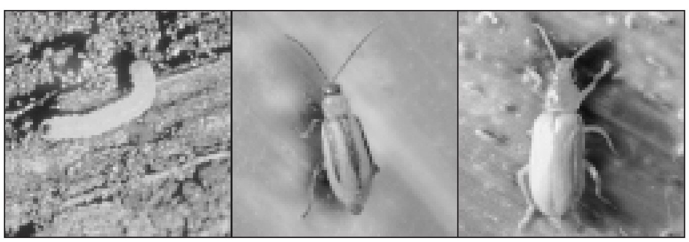
Insecticide Resistance: None.

References

C. L. Metcalf and R. L. Metcalf (1993) Destructive and Useful Insects, their Habits andControl 5th Ed. McGraw-Hill Book Co., New York.

Corn Rootworm

Scientific Name: *Diabrotica barberi,*
Diabrotica virgifera virgifera
Order: Coleoptera
Common Names: Northern Corn Rootworm,
Western Corn Rootworm



General Information

Biological Description

Fully grown larvae of northern and western corn root worms are approximately 1/2 inch long and the diameter of a medium pencil lead. Their heads are brown to black and there is a dark plate on the dorsal side of the alast abdominal segment. Northern corn rootworm beetles are approximately 1/4 inch long and pale yellow to tan in color when they first emerge from the soil. As adults mature, they become light green. The western relative is also 1/4 inch long but is characterized by the alternating yellow and black stripes along the back of the female. The male is also yellow and black but the wing covers are more uniformly black and lacks the striping present on females.

Economic Importance

Northern and western corn rootworms are two of the most destructive insect pests of sweet corn in the southern two-thirds of Wisconsin. Damage results from both root feeding by the larvae and silk clipping by the adults. In addition, the western corn rootworm also feeds on the leaves.

Life Cycle

Both species of corn rootworm beetles overwinter as eggs in the upper soil layers. In the spring. Eggs complete development and larvae emerge and begin invading corn roots. The first instar larvae begin feeding on the smaller branching corn roots. Later, the rootworms migrate toward roots at the base of the plant. Larvae may be present throughout the summer but commonly, larval damage peaks in mid-July. After three weeks, three larval instars have been completed and the larvae enter the pupal stage. Pupae are white and resemble the beetle. Typically they are found near the plant base but pupae have been recovered over 2 feet away. After a day or two the adult beetles emerge. Adult corn rootworm beetles are pollen feeders and are often found on ornamental flowers as well as vegetables. A three year study at the UW Arlington Research Station revealed that adults typically appear between July 16-24. The western corn rootworm adults appear slightly before those of the northern corn rootworm and the western corn rootworm male beetles begin to emerge before the females. Females begin laying eggs approximately two weeks after mating. In Wisconsin, this starts in early to mid-August and continues well into September. While the reproductive potential of each female beetle is 1000 eggs, 300-500 eggs are more common. The eggs enter diapause, a resting state in which they will overwinter.

Development and maturation occurs in the spring. There is one generation per year.

Host Range

Sweet corn, field corn and other grasses.

Environmental Factors:

Soil moisture influences both the number of eggs laid as well as the location of oviposition. Corn rootworm beetles lay more eggs in moist soil than dry soil. The higher the soil moisture, the closer to the surface the eggs are laid. Low soil temperatures in the winter as a result of little snow cover may contribute to high egg mortality of the western corn rootworm.

Damage/Symptoms

Rootworms cause damage by tunneling in corn roots. Evidence of corn rootworm activity consists of brown, elongated scars on the root surface, tunnels within the roots and varying degrees of root pruning. Lodging of plants caused by root pruning is common after storms containing heavy rains and high winds. Slight to moderate lodging can result in reduced ear weight and a goose-necked appearance in the plants. Adult corn rootworm beetles feed on green corn silks, thereby reducing pollination. This often results in poor ear fill. The western corn rootworm also feeds upon corn leaves. Sweet corn planted after early peas are more susceptible to adult leaf feeding injury (western) and silk pruning by both species because beetles are attracted to fresh pollen and silk. These late-planted fields will attract beetles from surrounding, more advanced fields.

Scouting Procedure and ET

Because corn rootworm beetles can reduce yield by silk pruning, it is important to scout sweet corn fields during pollination. Growers should begin checking for adults beetles before 70% of the plants are in the process of silking. Count the number of beetles on 10 random plants in five separate areas for a total of 50 plants. This should be done for each variety and planting date. Record the number of beetles per plant and the number of plants with silks clipped to 1/4 inch or less. In addition, record the number of plants that haven’t begun to silk, the number with fresh silk and the number with brown silk.

In addition to determining the potential for corn rootworm damage in the current year, scouting will also provide insight into the potential for damage if corn is planted in the field during the following year. Beginning in late July, scout corn acreage three times at 7 - 10 day intervals through mid September. Count the number of western and northern corn rootworm beetles on 50 plants each time you sample. Examine 10 plants at each of five areas in the field. Move quietly through the field so as not to disturb the beetles. Count the beetles on the entire plant. When you check the ear, grasp the ear tip tightly, enclosing the silks in the palm of your hand and count all other areas of the plant first. The silks often have the most beetles on the plant, so a tight hold on the ear tip keeps beetles from dropping. Examine the ear tip by cutting off about 1 inch of the tip. Open your hand slowly and count the beetles that come out of the silks as you strip the husk away from the ear tip. Pull leaves away from the stalk to adequately examine leaf axils. By determining the level of infestation this year, you may be able to determine whether preventative corn rootworm insecticide treatments will be necessary the following year. You will need to use a soil insecticide or rotate to a crop other than corn if you find an average of 0.75 beetles per plant during any of the three field samplings.

Integrated Control

Non-Chemical Control

Natural Control: While adult and larval corn rootworms are essentially free of parasites, ground beetles and predacious mites may control rootworm populations by feeding on eggs, larvae and pupae.

Cultural Control: Crop rotation is an excellent means of controlling corn rootworm populations. Although problems with extended diapause (northern) or egg laying in soybeans (western) have been noted in areas outside of Wisconsin larvae cannot survive if a crop other than corn is planted in an infested field. In addition, crop rotation will reduce the potential for developing strains of rootworms which are resistant to various insecticides. Planting early season corn will also reduce the severity of the injury caused by adult silk clipping because most of the corn will be finished pollinating by the time beetle emergence peaks.

Biological Control: None.

Chemical Control

Commercial: Chlorpyrifos, ehtoprop, fonofos, phorate and terbufos are registered to control corn rootworm larvae in sweet corn. All insecticide treatments should be made at the time of planting and in accordance with label directions. The preferred method is to apply a 7-inch band of granular insecticide ahead of the planter presswheel at planting. For the control of adult beetles, carbaryl, esfenvalerate, methomyl, encapsulated methyl parathion, and permethrin may be used once threshold levels have been reached. See Extension Circular A3422 for detailed information.

Insecticide Resistance: None.

References

Vegetable Crop Scouting Manual. University of Wisconsin - Extension. 1994.

European Corn Borer

Scientific Name: *Ostrinia nubilalis*
Order: Lepidoptera
Family: Pyralidae

General Information

Biological Description

Eggs are white, overlap like fish scales, and are deposited on the lower leaf surface of corn leaves and near the midvein. If ears are present, moths will also lay eggs on the flag leaves at the tip of the ear. There can be as many as 30-40 eggs in each mass. As they develop, the eggs change to a creamy color. Just before hatching, the black heads of the larvae become visible inside each egg. This is referred to as the black-head stage and each egg reaching this stage usually hatches within 24 hours. Full grown larvae are 3/4-1 inch in length and grey to cream-colored with numerous dark spots covering the body. The pupae are brown, 3/4 inch long and cigar-shaped with segmentation evident on one-half of the body. The adults are nocturnal, straw-colored moths with a 1 inch wing span. Males are slightly smaller and distinctly darker than females.

Economic Importance

Insect contamination problems are especially severe in fresh market sweet corn and sweet corn grown for freezing on the cob. Infestation by the European corn borer may result in higher processing costs or consumer rejection.

Life Cycle

The European corn borer overwinters as mature 5th instar larvae in corn stalks and stems of weedy hosts. Spring development begins when temperatures exceed 50 degrees F. Pupation occurs in May with the first moths emerging in early June in southcentral Wisconsin. Peak emergence occurs in mid-June at 600 degree days (base 50). This generation usually infests corn and females will seek out the tallest field for egg laying, but early-planted snap beans can also be attacked. Adult moths are nocturnal and spend most of their daylight hours in sheltered areas along field edges. Female moths lay egg masses in the evening. The eggs hatch in 3-7 days depending on the temperatures and young larvae feed on leaves and in the midrib of the leaves for 5-7 days (125 DD_{50}) before boring into stems and if available, bean pods. Boring usually begins with the third instar. The larvae pass through five instars and complete their feeding and development while boring inside stems. The earliest larvae to mature embark upon a 12 day pupal period within the stalk after which time the adult moths emerge. This begins the second generation. Late-maturing larvae go into diapause (a pause in development) and overwinter. Second generation moths peak in mid-August when approximately 1700 DD_{50} have been reached. Newly hatched second generation larvae tend to migrate to leaf sheaths and beneath ear husks. Larvae enter the silk channel at the tip of the ear, tunnel up the shank and into the ear, or bore directly through the husks and into the ear. All mature 2nd generation larvae enter diapause in late September and October and overwinter. In seasons with unusually warm spring and summer temperatures, some of the second generation larvae will pupate, emerge as moths and lay eggs for a late-season, third generation of larvae. These larvae do not have a chance to become fully grown before cold weather arrives and ultimately will perish.

European Corn Borer Development (DD base 50)

First Generation	Accumulated DD
First moth	375
First eggs	450
Peak moth flight	600
Larvae present	800-1000
2nd generation adults	1550-2100

Host Range

Corn borers attack over 200 different kinds of plants and may cause serious damage to sweet corn, peppers, potatoes and snap beans.

Environmental Factors

Cool weather or drought may delay spring insect development due to the desiccation of eggs and young larvae. Conversely, warm weather and moisture may accelerate insect development. Excessive heat and drought in spring may cause increased mortality of all stages. The number of eggs laid is affected by the availability of drinking water of which, dew is considered an important source. Heavy rainfall will decrease moth activity and drown newly-hatched larvae in whorls and leaf axils, or even wash them from the plant.

Damage/Symptoms

Damage to corn is caused by early larval stages chewing on the leaves and later larval stages tunneling into the stalks, ears and ear shanks. Early leaf feeding appears as pinholes, called "shotholes", as leaves emerge from the whorls. Third instar larvae begin to burrow into the midrib of the leaf, eventually working their way to the stalk. Severe feeding damage will result in broken stalks and tassels, poor ear development and dropped ears in dent corn. Insect contamination is a major concern in canned corn but problems are especially severe in fresh market sweet corn and corn frozen on the cob because of higher processing costs or consumer rejection in the finished product.

Scouting Procedure/ET

Processing Sweet Corn

Sweet corn planted for processing matures later than fresh market corn and European corn borer egg hatch begins ahead of tassel appearance. As a result, leaf feeding should be used as the primary indicator of infestation. However, early planted, early maturing varieties of processing sweet corn should also include egg mass counts when scouting. Late planted processing corn is subject to larval attack from the second generation larvae. Black light traps should be used to monitor adult corn borer activity. Moth catches provide data on the time of appearance and potential severity of the subsequent larval infestation.

In pre-tassel corn, examine 10 random sets of 5 consecutive plants each for a total of 50 plants and record the number with whorl feeding and eggs. For first generation corn borer, scouting for egg masses and whorl feeding should begin when 700 DD_{50} have accumulated. Pull the whorl from one infested plant per set, unroll the leaves and record the number of larvae found. This will give you an indication of the intensity of infestation. Younger larvae will be found feeding on the leaves in the whorl or behind the leaf sheaths. More mature larvae, third instar or later, will be found boring in the stalk or in the midrib where insecticide can't reach them. Larvae should be recorded by instar. The following approximate measurements will assist in determining the instar (larval stage) present: 1/8 inch = first instar, 1/4 inch = 2nd instar, 1/2 inch = 3rd instar, 3/4 inch = 4th instar and 1 1/4 inch = 5th instar.

In tasseling corn, or corn with tassels, the second generation of European corn borer may be present. The plants no longer have a whorl so you only need to scout for eggs. Pay close attention to the flag leaves on the ear tips. Ninety percent of the eggs will be laid on leaves in the first 1-2 nodes above the ear and the first 1-2 nodes below the ear. Strip off the lower leaves from the plant and careful examine the lower leaf surface for unhatched egg masses or the remains of hatched egg masses. Do not remove the upper leaves but examine the lower leaf surfaces for egg masses. Record the number of egg masses found and multiply by 2 to determine the total number of egg masses per 100 plants. When an egg mass is found, record its stage of development as follows: white = eggs are newly laid, cream = intermediate development, black-head = will hatch in a few hours and hatched.

Treat processing corn for first-generation borers if 15% or more plants have eggs or show leaf feeding. Repeat after 5-7 days if more than one unhatched egg mass remains per 10 corn plants. Granules should be used only before tassels emerge. Second generation borer control in August is usually required for late-planted sweet corn. Begin treatment when the first eggs hatch in mid-August. Scout every 5-7 days and sample at least five consecutive plants in 10 areas of a field. Accumulate your egg counts and treat if you average one egg mass (hatched plus unhatched) per 10 plants. Repeat every 5-7 days, depending on the insecticide selected and moth activity, as long as unhatched egg masses remain above one per 10 plant.

Fresh Market Sweet Corn

Sweet corn grown for fresh market production may be tasseling in June in southern WI when the first generation egg masses begin to hatch. Therefore, an egg mass count is required every 5-7 days once moths start to fly. Early evidence of borer attack must be detected so that insecticide applications may be timed to keep ears borer-free. Large fields of sweet corn grown for fresh market sale should be scouted as described above.

Treat fresh market sweet corn when 10% or more of the corn plants have egg masses. Start treatments at first hatching in mid-June and repeat every 5 days as long as 1 or more unhatched egg masses remain per 10 plants. Second generation control in August is usually required for late planted sweet corn. Begin treatment when the first eggs hatch (mid-August) if there is at least 1 egg mass per 10 corn plants. Continue treatment every 5-7 days, as long as hatched and unhatched egg masses remain above 1 per 10 plants. A black-light trap can also be used to follow adult activity and determine peak adult emergence.

Integrated Control

Non-Chemical Control

Natural Control: Weather conditions greatly influence European corn borer survival, particularly during the egg stage and while young larvae are feeding on the leaves. Heavy rains wash the egg masses and young larvae off the plants and thus can greatly reduce borer numbers. In addition, very hot, dry weather causes desiccation of the eggs and young larvae. These climatic variables will kill 22-68% of the freshly hatched larvae. Predators, parasites and disease also take their toll on European corn borer populations, however there is no way to predict the impact of these factors.

Cultural Control: There are no commercially-acceptable corn borer tolerant or resistant varieties. Plowing under crop stubble and shredding stalks on a community-wide scale in the fall to destroy overwintering larvae will reduce borer populations. Most corn borer damage occurs in late planted sweet corn (planted mid-June - early-July). However, moldboard plowing of fields is often unacceptable because of the potential for soil erosion. This, plus the fact that moths can fly several miles, and the wide host range of the European corn borer, limit the value of plowing under or shredding corn stubble. Fields planted before late May avoid second generation corn borer damage. Eggs and small larvae that are present within 12 days of harvest are of little importance in processing sweet corn (except frozen whole-ear corn). The small larvae are usually washed out in the processing line.

Biological Control: Predators, parasites and disease also take their toll on European corn borer populations, however there is no way to predict the impact of these factors making them a less practical alternative.

Chemical Control

Commercial: There are several insecticides which may be used to control European corn borer in sweet corn although the synthetic pyrethroids and micro-encapsulated methyl parathion are the insecticides of choice for commercial sweet corn. Bacillus thuringiensis is also effective in controlling early instar larvae of the European corn borer. Refer to the product label for specific application instructions and precautions.

Homeowner: Treat sweet corn with Sevin when 25% plants show larval feeding damage.

Insecticide Resistance: None.

References

R. H. Davidson and W. F. Lyon (1979) Insect Pests 7th Ed. of Farm, Garden, and Home. John Wiley & Sons, New York 596 pp.

K. F. Harris and K. Maramorosch, Eds. (1980) Vectors of Plant Pathogens. Academic Press, New York 467 pp.

C. L. Metcalf and R. L. Metcalf (1993) Destructive and Useful Insects, their Habits and Control 5th Ed. McGraw-Hill Book Co., New York.

Hop Vine Borer & Potato Stem Borer

Scientific Names: *Hydraecia immanis*, *Hydraecia micacea*
Order: Lepidoptera
Family: Noctuidae

General Information

Biological Description

Hop vine borer larvae are white with violet transverse bands. The head is orange to reddish-brown. Just prior to pupation, the violet bands disappear. By comparison, the larvae of the potato stem borer are white with reddish dorsal bands. The potato stem borer is a European relative of the hop vine borer and is almost identical in appearance but has a much wider host range. The distinctive coloration of the hop vine borer and potato stem borer will distinguish them from cutworms. Adult moths of both the hop vine borer and potato stem borer are non-descript brown to tan moths.

Economic Importance

The hop vine borer is a native, stem-feeding caterpillar that has caused localized damage to sweet corn in portions of Wisconsin, Iowa, Illinois and Minnesota.

Life Cycle

These insects overwinter as eggs which were laid on grass stems the previous August. Larvae hatch from the eggs in May and begin feeding on grass stems and rhizomes. In late May, second or third instar larvae move from grassy weeds into adjacent corn to complete development. Larvae complete development after tunnelling in the below-ground portions of the stem in late June to mid July. Larvae pupate in the soil within a few inches of the last host plant. The pupal stage lasts 4-6 weeks and adults are present from late July until early September. There is only one generation per year.

Host Range

The potato stem borer feeds primarily on potato, eggplant and other solanaceous weeds while the hop vine borer prefers corn, hops, and various grasses.

Environmental Factors

Reduced tillage and poor grassy weed control favor both the hop vine and potato stem borers.

Damage/Symptoms

Damage is usually confined to the outer four to six rows of sweet corn fields as the larvae migrate into corn from adjacent grassy areas. However, if corn follows sod or grassy weeds, outbreaks may be found throughout the field. The first indication of a hop vine borer or potato stem borer infestation is wilted corn plants. Unlike the common stalk borer which tunnels mainly in the corn stalk above ground, the hop vine and potato stem borers usually feed on the stem below ground.

Scouting Procedure and ET

To check for suspected hop vine and potato stem borers, remove damaged corn seedlings along with a 3-4 inch cube of soil. Look for entry holes in the stalk just below the soil surface, split the stalk, and sift through the soil. You may have to dig and examine several plants before finding any larvae.

Integrated Control

Non-Chemical Control

Natural Control: The skunk is the only known natural enemy of hop vine borer and potato stem borer. However, skunks often cause additional damage to corn plants by digging the plants in search of the borers.

Cultural Control: Adequate management of grassy weeds is the primary means of successfully controling both of these borers.

Biological Control: None.

Chemical Control

Commercial: There are no registered insecticides for the control of hop vine and potato stem borers.

Insecticide Resistance: None.

References

C. L. Metcalf and R. L. Metcalf (1993) Destructive and Useful Insects, their Habits andControl 5th Ed. McGraw-Hill Book Co., New York.

Seed Corn Beetle

Scientific Name: *Stenolophus leconti* (striped)
Flivina impressifrons (slender)
Order: Coleoptera
Family: Anthomyiidae

General Information

Biological Description:
Striped and/or slender seed corn beetles can be common in sweet corn fields. The striped seed corn beetle is dark brown with a brown to tan longitudinal stripe on each wing cover. The slender seed corn beetle is uniformly chestnut brown.

Life Cycle

Many aspects of their life cycle are not known but it is believed they overwinter as adults or perhaps as pupae. Adults appear during the first warm days of April. Larvae live in the soil and are believed to be predacious on other insect forms.

Damage/Symptoms

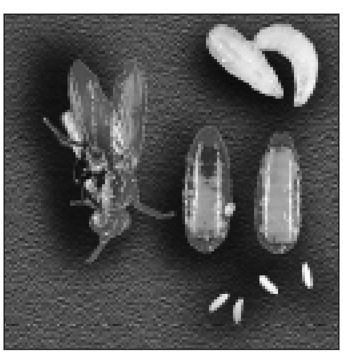
Planting to early seedling emergence is the critical period for the seed corn beetle. Only the adults attack the germinating seed and, in fields with poor germination, seed corn beetles can often be found feeding inside the seed. Light damage to the endosperm may not be significant but, if the germ is damaged, the entire plant may be lost. They can also damage the emerging sprout. As with the seed corn maggot, damage is worse during years with delayed seedling emergence.

Scouting Procedure

Scheduled scouting for seed corn beetles is unnecessary. However, if you find wilted, yellowed or stunted plants during sweet corn seedling stand counts, or during cutworm or other soil insect scouting activities, check for seed corn beetless. If numbers justify it, check 50 plants in 5 areas of the field (250 plants). Dig up and examine damaged seedlings and search for seeds in areas that have no plants. Unlike the spotty nature or wireworm damage seedcorn beetle damage will usually cover most of the field.

Seed Corn Maggot

Scientific Name: *Hylemya platura* (Meigen)
Order: Diptera
Family: Anthomyiidae



General Information

Biological Description
The yellowish-white larvae are typical fly maggots, 1/5 inch long when fully grown, cream colored, legless and wedge-shaped with the head end sharply pointed. Pupae are brown, 1/5 inch long, cylindrical in shape, and rounded on both ends. Adults resemble miniature houseflies; they are dark grey, 1/5 inch long and their wings are held overlapped over their bodies while at rest. Flies are smaller than cabbage and onion maggots, with whom they are easily confused. Eggs are about 1/32 of an inch in length, oval, and white.

Economic Importance

Although seedcorn maggot is a threat to sweet corn, damage is not as severe as that found on other vegetables such as peas and succulent beans. Additionally, growers usually use a soil insecticide at planting time for corn rootworm control. This also controls the seedcorn maggot.

Life Cycle

The seedcorn maggot overwinters as pupae in the soil. Peak adult emergence from overwintering pupae occurs anytime from early to mid-May when degree day accumulations have reached 200 DD_{39} Newly emerged adults may be seen flying in large numbers over recently-tilled fields. Adults mate within 2-3 days of emergence and females lay eggs in soils containing high organic matter or near seeds and seedlings of a wide variety of plants. Egg hatch occurs in 2-4 days. Larval feeding, development and pupation all occur below ground and the subsequent generation of adults appears 3-4 weeks later. This sequence of events is repeated and 3-5 generations of seedcorn maggots may occur during a season.

Host Range

Seeds and seedlings of most vegetable crops including beets, cabbage, corn, cucumbers, peas, radishes, squash, turnips, and kidney, lima and snap beans.

Environmental Factors

Cool, wet weather favors this insect while hot, dry weather is detrimental to its survival. Therefore, the seedcorn maggot is more likely to be a problem during the spring and early summer than later in the season. Cool, wet springs and doughty conditions may delay seed germination and lead to increased damaged by the seedcorn maggot. The application of livestock manure and incorporation of vegetation prior to egg laying makes fields more attractive to the female flies. Tillage of live plant material is more attractive than tillage of dead plant residue. The decomposition of the green vegetation may produce compounds that attract the flies.

Damage/Symptoms

All parts of sprouting sweet corn seeds are attacked by the maggot larvae, resulting in weakened, stunted plants and poor germination rates. Plants which survive maggot damage to the seed often have holes in the first pair of true leaves. Extensive feeding on seed endosperm can reduce plant vigor and contribute to “nubbin” ears. Larvae feeding on the seed germ will destroy the seed and prevent seedling emergence. Unlike the spotty nature of wireworn damage, seedcorn maggot damage will usually cover most of the field.

Scouting Procedure and ET

Seedcorn maggot damage cannot be detected until it is too late to take control actions. Therefore, economic thresholds for this insect are not useful and insecticides are applied at planting as a protective measure. However, if you notice wilted, yellowed or stunted plants, or seedlings with pinholes in the leaves check for seedcorn maggots. If numbers justify it, check 50 plants in 5 separate field areas. To monitor adult populations, place pans filled with soapy water along the field edge at 100 ft intervals. Flies trapped in the water should be removed every 4-6 days at which time fresh soapy water should be added. Records of the number of flies trapped will indicate when fly numbers are building up or tapering off. Forecasting the appearance of generations may be accomplished by accumulating degree days beginning when the ground thaws in spring. Degree days are calculated each day using the formula ((maximum temperature + minimum temperature)/2)-39. A running total of degree days is kept and peak emergence of the first three generations will occur when totals of 200, 600 and 1000 day degrees, respectively, have been reached.

Integrated Control

Non-Chemical Control

Natural Control: Naturally occurring fungal diseases occasionally will reduce seedcorn maggot numbers significantly, particularly when flies are abundant and relative humidity is high. During a fungal epidemic, dead or diseased flies can be seen clinging to the highest parts of plants along field edges. Predaceous ground beetles, which eat seedcorn maggot eggs, larvae and pupae can also be important in reducing maggot numbers. Because these soil-inhabiting beetles are susceptible to insecticides, broadcast soil insecticide treatments should be avoided whenever possible.

Cultural Control: Since the seedcorn maggot is attracted to decaying organic matter, fields where animal or green manure has recently been applied should not be planted. Plant seeds as shallow as feasible to speed germination. Any procedure which promotes fast germination and seedling growth will reduce chances of maggot infestation. In addition, home gardeners may soak seeds in water for about 2 hours prior to planting to promote fast germination and seedling growth. It is also possible to avoid seedcorn maggot damage by planting during fly-free periods that occur between generations of flies (see Scouting/ET).

Biological Control: None.

Chemical Control

Commercial: Chlorpyrifos, diazinon, fonofos, phorate and terbufos are all labeled for control of seedcorn maggots. Insecticides should be applied in the row at planting time. Make sure that fonofos and phorate do not come in contact with the seed. Planter box seed treatments containing diazinon and lindane can be mixed with the seed immediately before planting to control seed maggot in lieu of a soil insecticide at a considerable cost savings. Refer to the product label for more information on specific application instructions and precautions.

Insecticide Resistance: None.

References

R. H. Davidson and W. F. Lyon (1979) Insect Pests 7th Ed. of Farm, Garden, and Home. John Wiley & Sons, New York 596 pp.

C. L. Metcalf and R. L. Metcalf (1993) Destructive and Useful Insects, their Habits and Control 5th Ed. McGraw-Hill Book Co., New York 1087 pp.

S. M. Sanborn, J. A. Wyman and R. K. Chapman. “Threshold Temperature and Heat Unit Summations for Seedcorn Maggot Development Under Controlled Conditions.” Annals of Entomology. Vol. 75, No. 1 103-106.

Stalk Borer

Scientific Name: *Papaipema nebris*
Order: Lepidoptera
Family: Noctuidae

General Information

Biological Description

The larvae are purplish-brown with longitudinal, off-white stripes running the length of their body. There is a purplish saddle band located behind a yellow head. They range from 1/2 to 1 1/2 inches long and are extremely active when disturbed. Adult moths have dark grey-brown forewings with numerous small, white spots. The wingspan is approximately 1 1/4 inches.

Economic Importance

Damage to sweet corn by the common stalk borer and other borers besides the European corn borer tends to be localized and less common. In recent years however, this insect has become relatively common in some parts of the state.

Life Cycle

Adult female stalk borers lay up to 2,000 eggs in late August and September in grassy weeds, ragweed, pigweed, curlydock, burdock. The eggs overwinter and hatch in early spring (mid-April to early May). The tiny caterpillars can cause pinhole feeding in the leaves of seedling corn in late May in southern Wisconsin. As the larvae grow, the grass stems become too small and by late May to early June larvae begin to migrate from the grassy field borders into the border rows of adjacent crops. Larvae are fully grown in late August and may bore into many stems before pupating in the soil. Adults emerge 2-6 weeks later (late August) and seek grassy areas in which to oviposit. There is one generation/year.

Host Range

The host range of the common stalk borer is comprised of over 170 species. This insect attacks virtually any plant large enough for it to bore into, including all beans, corn, and potatoes.

Damage/Symptoms

There are basically two types of damage caused by the common stalk borer in sweet corn. In the first, the larva enters the corn plant near the base of the plant and tunnels within the stem. Stem tunneling in seedling plants causes unfurled leaves to wilt and flag. Seedling plants may be killed by this tunneling activity, and the larva will move to another plant if the food supply is exhausted. In the second case, the stalk borer larva enters the whorl and feeds there before tunneling downward. This results in numerous larval droppings (frass) and a series of irregular holes in the unfurled leaves.

Scouting Procedure/ET

Damage may appear severe on field margins, but on a whole field basis usually involves less than 2% of plants. Record number of wilted plants/100 throughout the field to determine an average. Control is suggested if 25% of the plants are infested.

Integrated Control

Non-Chemical Control

Natural Control: Populations seem to build and decline in 4-6 year cycles but the reasons for this are not understood. Natural enemies of the common stalk borer include a tachinid fly (*Gynmochaeta ruficornis*), an ichneumonid wasp (*Lissonota brunner*) and two brachonid wasps (*Meteorus leviventris* and *Apanteles papaipemae*).

Cultural Control: Cultural control is by far the most important control for this pest. Poor weed control during the previous year provides numerous oviposition sites and can result in extensive patches of crop damage the following year. Keep fall weeds, especially grasses, controlled to prevent egg laying. Mowing fence rows in mid-August as eggs are laid may also help to reduce next season's populations.

Biological Control: There are no commercially available biological control agents which are cost effective to use to reduce stalk borer populations.

Chemical Control:

Commercial: Insecticidal spray programs must be accompanied by a well-planned scouting program. Post emergence insecticides will effectively control this insect pest, but application timing is critical. During most years, sprays need to be applied during late May or early June before considerable wilting is present. Esfenvalerate, chlorpyrifos, and permethrin are labeled for use in sweet corn. Sprays applied much beyond the seedling stage of corn are of questionable value. Refer to the product label for more information on specific application instructions and precautions.

Homeowner: Cultural controls are recommended.

Insecticide Resistance: None.

References

J.L. Wedberg & B.L. Giebink. (1986) UWEXnote 5 - Stalk-Boring Insect Pests of Corn. University of Wisconsin Agricultural Bulletin Office. Madison, WI 4 pp.

R. H. Davidson and W. F. Lyon (1979) Insect Pests of Farm, Garden, and Home. 7th Ed. John Wiley & Sons, New York 596 pp.

C. L. Metcalf and R. L. Metcalf (1993) Destructive and Useful Insects, their Habits and Control 5th Ed. McGraw-Hill Book Co., New York.

White Grub

Scientific Name: *Phyllophaga spp.*
Order: Coleoptera
Family: Scarabidae

General Information

Biological Description

Grubs are white-bodied, 1/2-1 1/2 inches, sluggish, C-shaped larvae with brown heads and six prominent brown legs. The hind part of body is smooth with body contents showing through skin. True white grubs are distinguished from similar larvae by 2 rows of minute hairs on the underside of the last segment. Adults are the common brown to black May or June beetles seen in the spring. There are several species of white grub in Wisconsin; they typically have 3-year lifecycles. Their activity is primarily nocturnal.

Economic Importance

White grubs are typically only a problem in sweet corn planted in a field which had been in sod the previous year. In row crop fields, the incidence is reduced.

Life Cycle

Most species have a three year life cycle in Wisconsin. Adults emerge and mate in late May to early June. Females search out grassy areas, burrow into the soil and deposit eggs. Eggs hatch in 2-3 weeks and grubs begin feeding on roots and underground plant parts. With the onset of cold weather, the grubs move beneath the frost line in the soil to overwinter. In late May, to early June the grubs migrate back to the surface soil horizons. It is during the second year that the most damage is done as larvae increase in size before they return to the subsoil layers to overwinter. In the third spring, the grubs return to the surface, feed for a short time and pupate. In late summer, adults emerge from the pupae but remain underground until the following spring. Peak adult flights occur in Wisconsin every three years and historically have been noted in 1980, 1983, 1986, 1989, and 1992. The years following peak adult flight characteristically are peak larval damage years (1981, 1984, 1987, 1990, and 1993).

Host Range

Many species of crops are attacked. All vegetables, strawberries, roses, nursery stock, and most grass and grain crops are susceptible to grub damage.

Environmental Factors

White grub injury is typically a problem in areas which were previously planted to sod.

Damage/Symptoms

Damage is usually patchy, rather than randomly distributed throughout the field. They do not damage planted corn seed but rather prune and destroy corn roots and can feed on corn stalks below ground. Small areas of infested fields may be totally destroyed. Plants may be wilted, stunted and, with heavy infestations, can easily be lifted from the ground. Damage is most severe in years following peak adult flights and is most pronounced in crops following sod or fields with grassy weeds.

Scouting Procedure/ET

Routing scouting is not suggested. However, damage may be observed during seedling stand counts or cutworm surveys. If signs of white grub damage are found, count the number of grubs on 25 plants in five areas of the field. Dig plants suspected of being infested and examine the roots for signs of pruning. Search for grubs in the soil immediately surrounding the root zone. Record the number of damaged plants and number of grubs found.

Integrated Control

Non-Chemical Control

Natural Control: A parasitic fly - *Pyrogota* spp. parasitizes the grubs and may reduce populations. Birds are effective predators in freshly plowed fields.

Cultural Control: The first year after sod or grassy, weedy alfalfa will be the most damaging. Keeping grass weeds down in spring will prevent egg laying. Use rotation to avoid planting sweet corn into infested fields following years of peak flights. Pasturing hogs on grub infested land will reduce the infestation.

Biological Control: Commercial preparations of milky spore disease are rarely effective.

Chemical Control:

Commercial: Chlorpyrifos may be applied as a broadcast application prior to planting. Chlorpyrifos and terbufos may be applied in the seed furrow as well as in a 7 inch band. Phorate may be applied as a 7 inch band. Refer to the product label for specific application recommendations and precautions. Application of insecticide after planting of corn will not control the grubs.

Homeowner: Apply diazinon (Spectricide) as a broadcast, preplant application.

Insecticide Resistance: None.

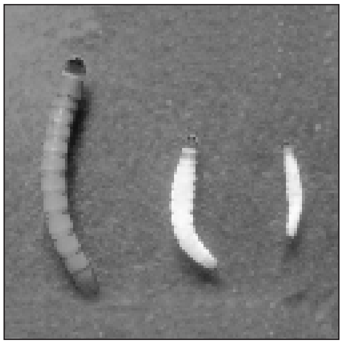
References

R.H. Davidson and W.F. Lyon (1979) Insect Pests 7th Ed. of Farm, Garden, and Home. John Wiley & Sons, New York. 596 pp.

C.L. Metcalf & R.L. Metcalf (1993) Destructive and Useful Insects, Their Habits and Control. 5th Ed. McGraw-Hill Book Co., New York.

Wireworm

Scientific Name: Many species and genera
Order: Coleoptera
Family: Elateridae



General Information

Biological Description:

The larvae of click beetles or wireworms are the damaging stage of this insect. Larvae are thin, yellow to reddish-brown, shiny, jointed, worm-like larvae, 1/4 to 1 1/2 inch in length by 1/8 inch in diameter. They are distinguished by the ornamentation on the last segment. Adults are hard shelled, brown or black "streamlined" beetles which flip into the air with an audible click if they are placed on their back.

Economic Importance:

Wireworms may be one of the more damaging pests of sweet corn.

Life Cycle:

Wireworms have an extended life cycle, taking from 1-6 years. In Wisconsin, wireworms overwinter as either adults or larvae.Larvae live in the upper six inches of soil and feed on seeds and roots. They migrate only short distances. They are sensitive to moisture and may burrow deeply into the soil in dry conditions. Adults become active in the spring as they fly about searching for a site on which to lay eggs. Adult females may live 10-12 months, spending most of this time in the soil where they may lay up to 100 eggs. Eggs are laid in soil in grassy areas. This includes pastures, alfalfa, sod, and grassy weed infestations in row crops. Egg hatch occurs in several days to weeks. Tiny larvae immediately begin to feed on the roots of grasses , weeds and other crops. Because of the extended life cycle, larvae of some species will feed for two to three years before pupating. Adults that emerge from these pupae remain in the pupal chambers until the following spring.

Environmental Conditions

Wireworms tend to be most damaging 1-4 years after plowing up sod or in poorly drained lowlands, but they are not exclusive to those areas.

Host Range

Wireworms feed primarily on grasses, including corn and small grains as well as nearly all wild and cultivated grasses. Favored row crops include beans, beets, cabbage, carrot, lettuce, onions, peas, potato, radish, turnips, sweet potatoes, cucumber, and tomato. Asters, phlox, gladioli, and dahlias are some of the more commonly infested herbaceous ornamentals.

Damage/Symptoms

Damage is most likely to occur when infested pastures or alfalfa sod are plowed under and planted to row crops. Because of the long life cycle of wireworms, damage is possible two to three years after the field is taken out of sod. A second year of corn after sod may have more damage than the first year, perhaps because there are fewer grass roots to feed on. In sweet corn, damage to the ungerminated seed occurs when wireworms hollow out the seed, thus preventing germination. Later, they feed on below ground portions of the stem. They drill a hole into the stem and occasionally drill completely through it. Stems of small seedlings may be hollowed out up to the soil surface. By midsummer, soil temperatures have increased and soil moisture is reduced. At this time, wireworms and their damage often appear to disappear when in fact the wireworms have merely migrated deeper into the soil. Early indications of wireworm damage to sweet corn is the lack of germination which results from the destruction of the seed. Only a few plants may remain in a heavily infested area. The first few leaves of emerging seedlings will often show a pattern of holes which is caused by wireworms feeding through the leaves before they unfurl. Stem feeding caused plants to wilt and die, further adding to the "spotty" appearance of the field. On larger plants, only the center leaves may wilt. If these plant do not die, they are usually stunted and distorted, and will not produce a normal ear.

Scouting Procedure/ET

Scheduled scouting is not suggested. However, symptoms of wireworm activity may be observed during seedling stand counts or cutworm scouting. No thresholds have been developed. If wireworm damage is suspected, dig up several ungerminated seeds or damaged plants along with a 4-6 inch core of surrounding soil and check for wireworms in and around the roots, or in the underground portion of the stems. Larvae may be extracted from the soil by washing or the application of heat to soil surface in funnels.

Integrated Control

Non-Chemical Control

Natural Control: Several natural enemies have been described but they are not effective in reducing populations.

Cultural Control: Crop rotations which avoid susceptible crops and clean cultivation may reduce wireworm numbers. Some species thrive in poorly drained soil and can be reduced by adequate drainage. Clean summer fallowing of infested fields has been effective in some areas. Certain soil types (e.g. silt loams) are particularly susceptible.

Chemical Control

Commercial: Insecticides registered for the control of wireworms in sweet corn include chlorpyrifos, ethoprop, phorate, and terbufos.

Insecticides should be applied in a 7 inch band or in the seed furrow. Refer to the product label for more information on specific application instructions and precautions. Application of insecticide after planting will not control wireworms.

Homeowner: Apply diazinon as broadcast, preplant applicationand work into top 6 inches of infested soil.

Insecticide Resistance: None.

References

R. H. Davidson and W. F. Lyon (1979) Insect Pests of Farm, Garden, and Home. 7th Ed. John Wiley & Sons, New York 596 pp.

C. L. Metcalf and R. L. Metcalf (1993) Destructive and Useful Insects, their Habits and Control 5th Ed. McGraw-Hill Book Co., New York.

Field Crop Insect Stages

Insect management decisions should be based on the potential for economic damage. In order to determine damage potential, the size and number of larvae and the number of remaining insect stages must be known. Certain insects can very quickly become major pests on field crops because as insects grow, they eat more each day.

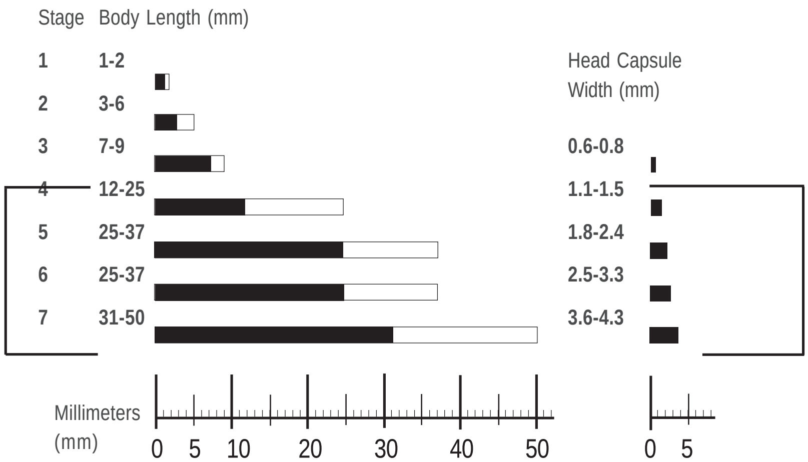
Although small larvae are usually not damaging, larvae can become devastating in a few days as they near maturity. Sixth-stage green cloverworm larvae, for example, may consume 75% of their larval food during the last six days of the 23-day larval life. Damage, however, will quickly subside after the insects have pupated.

As larvae grow, they molt, or shed their skins. The stage between molts is called the **instar**. Most field crop insects have 3 to 7 larval stages. For example, the European corn borer has 5 larval stages, the black cutworm has 7, and the western corn rootworm 3.

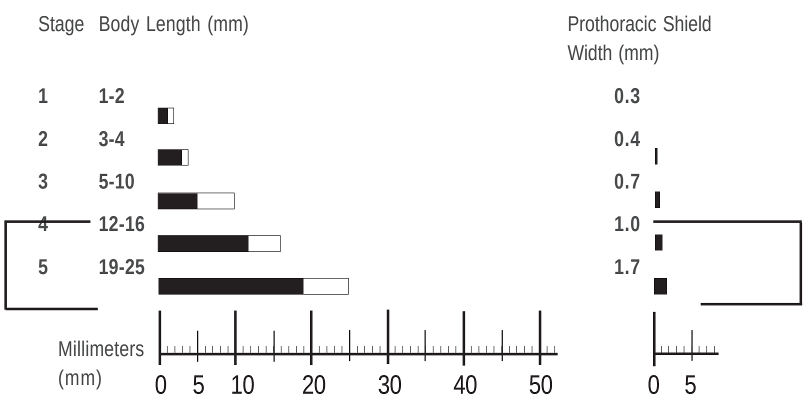
During a stage the larva's body grows but its head does not increase in size. Only between stages does the size of the head increase. Identification of larval stages can be partially determined by the length of the larva. The most accurate method, however, is measuring the width of the head capsule. An exception is the European corn borer, where measuring the width of the prothoracic shield is more accurate than measuring the width of the head capsule.

Head capsule (or prothoracic shield) measurements and approximate body lengths corresponding to larval stages are given for 7 common crop insects. Approximate lengths are illustrated. For body length measurements, the unshaded portion is the range corresponding to the particular larval stage. For example, for the fourth stage of black cutworm, the dark portion of the line is equal to 12 mm. The unshaded portion is the 12 to 25 mm range in body length for the fourth larval stage. The stages within the brackets are considered to be the most destructive.

Black cutworm—*Argrotis ipsilon (Hufnagel)*



European corn borer—*Ostrinia nubilalis (Hübner)*



All information in this Field Crop Insect Stages sheet, taken from Iowa State University of Science and Technology, Cooperative Extension Service, publication prepared by Jerry DeWitt, integrated pest management coordinator, and Harold Stockdale, extension entomologist at the Cooperative Extension Service, Iowa State University.

Field Crop Insect Stages

Armyworm—*Pseudaletia unipuncta (Haworth)*

Stage	Body Length	Head Capsule Width (mm)
1	2-4	0.4
2	3-6	0.6
3	5-10	1.0
4	11-15	1.5
5	14-21	2.4
6	24-25	3.4

Alfalfa weevil—*Hypera postica (Gyllenhal)*

Stage	Body Length (mm)	Head Capsule Width (mm)
1	1-2	0.2
2	2-3	0.2-0.3
3	4-6	0.4
4	6-8	0.5-0.6

Corn earworm—*Heliothis zea (Boddie)*

Stage	Body Length (mm)	Head Capsule Width (mm)
1	1-4	0.3
2	3-8	0.5
3	9-11	0.8
4	15-18	1.3
5	24-28	2.0
6	34-42	3.9

Western corn rootworm—*Diabrotica virgifera LeConte*

Stage	Body Length (mm)	Head Capsule Width (mm)
1	1-2	0.2
2	3-5	0.3
3	6-8	0.5

Green cloverworm—*Plathypena scabra (Fabricius)*

Stage	Body Length (mm)	Head Capsule Width (mm)
1	1-4	0.3
2	3-7	0.4
3	8-11	0.6-0.7
4	11-19	0.8-1.1
5	16-23	1.3-1.6
6	18-31	1.8-2.1

A Key to the Types of "Worms" Found in Corn & Alfalfa Fields

1. Worms without legs	1/8" to 1/2" long, often spindle-like or peg-shaped Maggots (fly larvae)
1^{1}. Worms with 6 or more legs	**2**
2. Worms with only 6 legs	Beetle larvae *Coleoptera*
2^{1}. Worms with more than 6 legs	**3** *(see figure 1)*
3. Worms with 6 pointed legs on front of body and 10 to 14 blunt legs on middle and rear of body	**4**
3^{1}. Worms with 15 or more pairs of legs, legs all of same size and shape, two pair of legs per segment	Millipeds—*(see figure 2)* feed on organic matter
4. Worms with 6 pointed legs on front, 10 or less blunt prolegs on middle and rear of body, each proleg has group of small hooks at tip	True Caterpillars—***Go on to next page***
4^{1}. Worms with 6 pointed legs, plus 14 blunt prolegs, no hooks on ends of proleg, only one pair of eyes on head	Sawflies—*(see figure 3)* feed on weeds

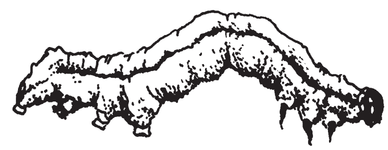


figure 1

figure 2

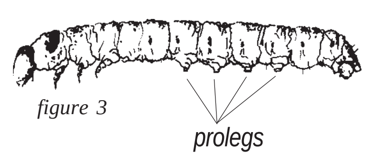


figure 3

Wisconsin Field Pest Caterpillar Key

This key has been put together to help in the identification of the more common general pest caterpillars in Wisconsin. It will by no means identify everything in the field, but should work for 80% of the worms found. Such things as when, what crop and where on the plant the insect is found are important aids in identification and are included whenever practical in this key. Read through the total description of each insect before making your decision on which direction to go. Most characteristics can be observed with a 10X hand lens. Looking at the skin texture will require good light and a 15-20X lens. Worms over 1" in length will be easier to work with. Whenever possible, a series of specimens should be used for ID purposes.

A. Two pair of ventral prolegs on abdomen — **B** *(see figure 1)*

figure 1

A[1]. Four pair of ventral prolegs present on abdomen — **C** *(see figure 4)*

figure 3

B. General color green, body thick with thin white line on side. Most often found in cole crops and potatoes. Does not appear until late July. — **Cabbage Loper** *Trichoplusia ni*

B[1]. General color light tan to pink, head with distinct white, brown or pink stripe. Usually associated with clover or alfalfa — **Forage Loper** *Caenurynia erechtea*

C. Caterpillar with very distinct, sharply defined stripes along back or sides — **D**

C[1]. Caterpillar without distinct, prominent stripes. May have indistinct bands or markings — **J**

D. Skin covered with densely packed microspines *(see figure 5)*. Larvae variable in color. Dark brown to green or yellow with lengthwise light and dark stripes. Found in corn silks, ears and tomatoe fruit. Not found in Wisconsin until July or later. — **Corn Earworm** *Helicopvera zea*

figure 5

D[1]. Skin not as above, but may have pebbly texture — **E**

E. Purple ringed area around middle of body. Body whitish with dark brown lateral stripes. Larvae most often boring into stem of corn, potatos, peppers, tomatoes during June and July.	**Common Stalk Borer** *Papipama nebris*
E[1]. No purple saddle around middle of larvae	**F**
F. Prominent light colored, inverted Y on head. Body tan, green or black. Back somewhat lighter colored, dark side stripes running length of body. Prothoracic shield usually with 3 pale yellow lines. Four spots (pinacula) arranged as points of square on back of next-to-last abdominal segment. Spiracles with lighter center. Found only in late summer in corn ears or rarely in grain fields.	**Fall Armyworm** *Spodoptera frugiperda*
F[1]. Body with various markings. Larvae not as above. Found throughout growing season, rarely found in corn ears.	**G**
G. Several thin, prominent bright yellow side stripes. Large black spot above first abdominal spiracle and double row of black triangular markings on most of back. Spiracle, gray center with dark rim (general feeder). Found on vegetables from mid June on.	**Yellow-Striped Armyworm** *Spodoptera ornithogalli*
G[1]. NO yellow stripes or black spot on first abdominal segment. Spiracle totally black or with white center. If black markings present on back, never present on more than 1/2 of larvae.	**H**
H. Spiracle white or yellowish center, prominent black chevron wedge shaped markings on last 2 abdominal segments. Pale pink or orange side stripe present. Large larvae found in Spring on alfalfa—Fall. General feeder. Often in mixed infestation of true Armyworm.	**Spotted Cutworm** *Amathes C-nigrum*
H[1]. Spiracle black. If markings on back, they are all defined and not as above.	**I**

I. No distinct lines on back. A row of 4-7 pale yellow spots along center of back. In dark colored forms, a black W-shaped spot found on last abdominal segment. Larvae black to pale brownish gray. Jaws with sharp teeth. General feeder. A climbing cutworm on tree fruits in Spring, strawberries, potato, general vegetables.	**Variegated Cutworm** *Paridroma saucia*
I[1]. Back of caterpillar with numerous lines running lengthwise. No light spots on back. Jaws without teeth. Light to pink side stripe present. Most common on corn and various small grains. From mid June and July. Often associated with weedy grasses.	**True Armyworm** *Pseudaletia unipunta*
J. Caterpillar with some striping on body—may be inconspicuous.	**K**
J[1]. Caterpillar with no stripes (may have small spots). All whitish or gray.	**N**
K. Caterpillar with several indistinct stripes on BACK.	**L**
K[1]. Caterpillar with no stripe or only one broad (or narrow) inconspicuous stripe on BACK.	**M**
L. Skin bearing coarse granular *(see figure 4)*. Caterpillar dingy brownish tan. Faint V-shaped markings on back. Spiracles black. Found on alfalfa, corn and vegetables.	**Dingy Cutworm** *Feltia ducens, F. subgothica*
L[1]. Skin smooth. Caterpillar dull gray with prominent dark gray side stripe above spiracles. Sides darker than back. Spiracles dark brown. On tree fruits, onion, potato, corn. Can climb.	**Dark Sided Cutworm** *Euxoa messoria*

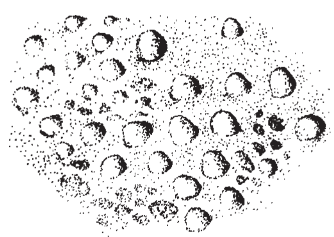


figure 4

M. Skin granules appear greasy under hand lens *(see figure 6)*. Body is light gray to black. Narrow indistinct striped down middle of back. No distinct spots. Spiracles and tubercles black. Most common cutworm in Wisconsin. Seen in corn, turf and vegetables.

Black Cutworm *Argrotis ipsilon*

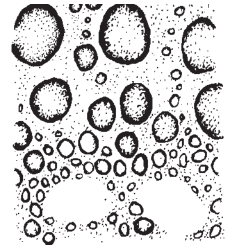


figure 6

M[1]. Caterpillar with skin granules, 4-6 sided *(see figure 7)*. Body pale gray with broad, tanish stripe on back. Spiracles black. Occasional pest of corn, strawberries, general vegetables.

Clay-Backed Cutworm *Argrotis gladiaria*

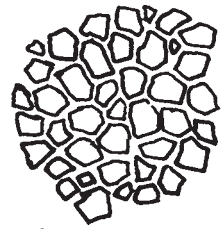


figure 7

N. Caterpillar with head and neck shield bright reddish brown. Body greasy white and very plump. No conspicuous markings or stripes on body. Spiracles brown, mandible with four distinct, blunt outer teeth and three inner teeth.

Glassy Cutworm *Crymodes devastator*

N[1]. Not as above. Head pale brown to black. Dull. Body normal size. Some spots or indistinct markings.

O

O. Head pale brown. Body semi-translucent with several white side stripes. Spiracles black. Larva limited to sandy soils. Most often feeding at or below ground level.

Sand Hill Cutworm *Euxoa detersa*

O[1]. Head dark brown to black. Body grayish to yellowish white. Distinct hair bearing spots on body. Spiracles light brown with yellow rim. Most often found boring into stem on fruit of the plant. Primarily on corn, tomato, pepper, potato.

European Corn Borer *Ostrina nubalis*

Managing Corn Earworm and European Corn Borer in Fresh Market Sweet Corn

K. A. Delahaut and J. L. Wedberg
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Two insect pests pose a problem as ear contaminants to sweet corn grown for fresh market sale. These insects are the corn earworm and the European corn borer. Fresh market sweet corn is susceptible to early and late season damage by one or both of these insects. Although earworms occasionally infest early-planted sweet corn, the first generation of the European corn borer is the primary cause of contamination in early-planted sweet corn while both the second generation of the European corn borer and the corn earworm may contaminate late-planted crops. Damage to corn results when larvae feed in the tips of the ears, devouring kernels and contaminating the ear.

Monitoring Sweet Corn Pest Populations

Corn earworms, which do not overwinter in Wisconsin, are easily monitored with the use of pheromone traps. Wire Hartstack traps and nylon-mesh Scentry traps may be used to monitor adult migrations. Traps should be placed 4-6 feet from the ground on the south or west side of a field in which the corn is in the green silk stage. Ideally, every silking sweet corn field should have its own trap. Traps should be in place by July 1 in Wisconsin to catch any early migrations that may occur. Traps should be moved to new fields entering the silking stage as the silk in the current field becomes brown. Pheromone lures should be changed every 2 weeks with the unused lures kept frozen until they are needed. Used lures should be removed from the trap area to prevent confusion of adult moths by more than one source of the pheromone. Traps should be checked daily once migration has begun. When five or more moths have been trapped for three consecutive nights in the Hartstack trap or two or more moths per night have been captured in the Scentry trap, treatment should be initiated. Scentry traps typically attract fewer moths than the wire Hartstack traps.

European corn borer adults can be monitored with blacklight traps. Unlike the corn earworm pheromone traps, blacklight traps do not need to be located on every farm. It is the developmental progression of this insect that is important and fields located within the same climatic regions may share a trap. Several newsletters provide information on blacklight trap catches on a weekly basis. However, growers of large acreages of sweet corn may be interested in investing in their own blacklight trap to identify what the populations are on their farm on a daily basis. Similarly, groups of smaller growers in a localized area may wish to form a network and purchase a blacklight trap so they can monitor European corn borers more frequently.

Optimum Treatment Time

The critical period for the management of ear contaminants in fresh market sweet corn is when plants are silking. Insecticides need not be applied to fields which are not silking. It is important to begin treatment when a sustained flight of moths is first detected in traps. A sustained flight is when several moths are caught on consecutive nights. Delays in treatment may result in a 10-15% reduction in clean ears for every day delayed. When applying an insecticide, it is important to get the material onto the corn plants near the ear. Spray equipment with nozzles directed over the top as well as toward the ear assure proper placement and good coverage of the target area. The objective is to get the insecticide onto the silks so developing larvae will ingest the material as they feed. Once the larvae enter the ear, they are protected by the plant and treatments will be ineffective. Aerial applications of insecticides are less effective than ground applications. Mist blowers have been proven ineffective in controlling corn borer and corn earworm larvae as they don't provide thorough coverage to the target area.

Control

Synthetic pyrethroids such as Ambush, Pounce, and Warrior (which are restricted use pesticides) are recommended for the management of both the European corn borer and the corn earworm. Ambient temperatures above 85 degrees may reduce the residual efficacy of synthetic pyrethroid insecticides. In addition, warm temperatures also accelerate the growth of both the corn and insect pests. Under warm conditions, egg hatch can occur within 24-48 hours after being laid. Consequently, spray intervals should be shortened to provide adequate protection to the rapidly emerging silk. Using the higher recommended rate of insecticide will not necessarily provide increased control. Also, the minimal increase in control may not warrant the increased cost. If there are fewer than 10 days to harvest, insecticide applications need not be made since the field will no longer be silking and any eggs being laid will not hatch before harvest. The larvae of both insects grow about 1/16th of an inch per day. By measuring any larvae found, a grower may determine when the infestation occurred and can compare this date with trapping records . Remember, only fields that have silked need to be treated. The tables below will help you determine the interval between applications.

Reference

Flood, B., R. Flood, and B. Hutchinson. 1995. Sweet Corn: Chapter 2 in Vegetable Insect Management With Emphasis on the Midwest. R. Foster and B. Flood eds.

Spray Schedule for Nightly Trap Catches

Temperatures Less Than 85° F.

Corn Borers	Corn Earworm Moths: <2 per night	2-5 per night	5-10 per night	10-50 per night	>50 per night
<5 per night	Do Nothing	Do Nothing	Do Nothing	4 day interval	3 day interval
5-10 per night	6 day interval	6 day interval	5 day interval	4 day interval	3 day interval
10-20 per night	5 day interval	5 day interval	5 day interval	4 day interval	3 day interval
>20 per night	4 day interval	4 day interval	4 day interval	4 day interval	3 day interval

Temperatures Greater Than 85° F.

Corn Borers	Corn Earworm Moths: <2 per night	2-5 per night	5-10 per night	10-50 per night	>50 per night
<5 per night	Do nothing	Do nothing	Do nothing	3 day interval	2 day interval
5-10 per night	5 day interval	5 day interval	5 day interval	3 day interval	2 day interval
10-20 per night	5 day interval	5 day interval	5 day interval	3 day interval	2 day interval
>20 per night	4 day interval	4 day interval	4 day interval	3 day interval	2 day interval

Disease Profiles

Anthracnose

Cause: *Colletotrichum graminicola*
Type: Fungus


General Information

Biological Description

Anthracnose is caused by a fungus which possesses both a sexual and an asexual stage; however, the sexual stage is rarely found. The fungus produces single-celled, curved asexual conidia within a fruiting structure called an acervulus. Acervuli are embedded within the epidermis of the plant, breaking through the epidermis when conida maturation is reached. Different isolates of the disease vary in their pathogenicity.

Economic Importance

Sweet corn anthracnose is considered a minor disease in Wisconsin. Severe disease outbreaks are reported on sweet corn in Indiana. Anthracnose has become more prevalent on field corn grown in Wisconsin. Thus this disease may become more prevalent on sweet corn in the future. This disease can cause up to 100% yield loss if environmental conditions favor its development.

Disease Cycle

The fungus overwinters in diseased plant debris and seeds. Seed-borne inoculum may remain viable for 3 or more years. Infected seed provides the source of primary inoculum. Spores are produced in the spring and are carried by wind or splashing rain to young corn seedlings where infection occurs through the leaf epidermis. Free water is necessary for spore dispersion and germination. Initial symptom development becomes apparent five days after infection. The disease is especially severe when warm, wet weather occurs in July or August. It affects all above ground parts of sweet corn plants and causes premature death and lodging. Asexually-produced conidia produced on plants during the growing season are spread by wind, rain, and insect movement to other plants in the field. Infection may occur through wounds although some isolates may infect susceptible hosts in the absence of wounding. Plants appear to be less susceptible during pollination than at any other time.

Host Rang

The fungus which causes anthracnose on sweet corn also infects dent corn, Bermudagrass, Guineagrass, Bungalowgrass, crabgrass, Guatemalagrass, Molassasgrass, Paragrass, and Merkergrass. Fungal isolates from corn do not infect sorghum, and the isolates from sorghum do not infect corn.

Environmental Factors

Disease development is most severe when there are extended periods of cloudy, warm, (60-90^{o}F), humid, wet weather in July and August. Drought stress early in the growing season followed by rainy, warm periods in July or August favors disease development on drought weakened plants.

Symptoms

Anthracnose can cause seedling blight, crown rot, root rot leaf blight, top dieback, stalk rot, and kernel infection. Leaf blight begins as small, round to oval, water-soaked yellow spots that occur anywhere on the leaf. Lesions are elongated and tapered at each end and range in size from 1/4-3/4 inch in diameter. They often have a yellow to reddish-brown border. Tiny black specks, or spore-producing structures develop in the center of lesions. Lesions may coalesce and leaves may die if infections are severe. Lesions may be light brown on resistant plants and are surrounded by a chlorotic zone.
Symptoms of stalk rot appear after tasseling as narrow, vertical, water-soaked lesions on the stalk rind. The lesions become tan to reddish-brown then black, and black specks are also produced in these lesions. Leaf sheaths must be removed to see these lesions. Invaded pith tissues turn dark and disintegrate. Plants with stalk rot are weakened and lodge. Top killing is usually seen after tasseling. Top killing causes premature death of all or part of the plant above the ear. Kernel infection appears as dark streaks which run the length of the kernel.

Scouting Procedure/ET

There are no formalized scouting procedures designed to monitor fields for anthracnose. Scouts should watch for symptoms of anthracnose, or any other foliar disease as fields are scouted for insect pests.

Integrated Control

Non-Chemical Control

Cultural: A 2 or 3 year crop rotation of sweet corn with nongrass crops usually gives adequate control of anthracnose infection since the fungus survives poorly in the absence of corn residues. Plowing under crop residues also reduces the source of inoculum since the fungus does not survive well in residues that are buried. The fungus grows abundantly on residues left on the soil surface. Fall plowing is more effective than spring plowing. In normal seasons, these cultural control measures usually are effective, however, in years where abundant rainfall occurs in July and August, the disease may still be a problem. Cultural practices leading to high soil fertility, good weed control, and early planting and harvest will help sweet corn withstand anthracnose damage.

Resistant Varieties: Genetic resistance to anthracnose is not available in commercial sweet corn hybrids at this time.

Chemical Control

Chemical seed treatments may be useful in reducing seed-borne inoculum. Mancozeb, maneb and chlorothalonil fungicide may protect healthy foliage in the event of an outbreak but preharvest intervals may preclude their use.

Fungicide Resistance: None.

References

Compendium of Corn Diseases. 1973. The American Phytopathological Society Inc., St. Paul, Minnesota. 64 pp.

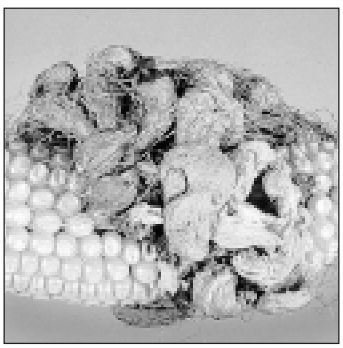
Nicholson, R.L., W.R. Stevenson, H.L. Warren, D.H. Scott and P.C. Pecknold. 1974. Anthracnose of sweet corn. Purdue University Extension Publication PP 8-14.

Sherf, A.F. & A.A. MacNab. 1986. Vegetable diseases and their control. John Wiley & Sons, Inc. 728pp.

Common Smut

Cause: *Ustilago maydis*

Type: Fungus



General Information

Biological Description

Common smut is caused by the basidiomycete fungus *Ustilago maydis*. Thick-walled, olive-colored chlamydospores are produced in the fruiting galls while the sexual sporidia are produced on special tissues which arise from the chlamydospores.

Economic Importance:

Common smut is the most widespread disease of sweet corn. It occurs worldwide wherever corn is grown. Losses from smut are variable ranging from a trace up to about 15%. Sweet corn losses appear to be greater than those from field corn. The number, size, and location of the galls on the plant affect the amount of yield reduction. In addition to reducing yield, common smut increases processing costs. Galls are produced when the fungus stimulates the corn cells to increase in size and number. Planting tolerant hybrids and using good horticultural practices should keep losses to less than 5%.

Disease Cycle

Chlamydospores from the galls overwinter in the soil. They are easily blown from one area to another by rain, farm machinery, insects and in dust storms. These spores germinate in moist air at temperatures ranging from 50-95^{o}F to produce other spore-like structures which are blown or carried in water to corn plants. The greatest incidence of infection occurs when the plants are in the leaf-whorl stage. Although wounds are not necessary for infection to occur, an increased incidence of infection may occur as a result of plant injury within two weeks of tasseling. Free water is necessary for initial infection to occur, however free water is no longer necessary once the plant has been infected.

Host Range

The smut fungus infects only sweet corn, field corn, and teosinte, a wild relative of corn.

Environmental Factors

Development of the smut galls is favored by temperatures between 79-93^{o}F. The incidence of disease is higher among plants grown in soils high in nitrogen or after manure applications. Injuries due to hail, blowing soil particles, herbicide injury,cultivation, buggy-whipping, or detasseling in seed fields greatly increases the potential for smut infection by providing entries for the fungus.

Symptoms

The symptoms of corn smut are usually conspicuous and easily recognized. All above-ground parts of the plant are susceptible, particularly young, actively growing tissues. This includes leaves, stalks, ears, and tassels. When the galls first appear, they are covered with a glistening, greenish to silvery-white tissue. The interior of these galls darkens and becomes masses of powdery, dark olive-brown to black spores, which may reach up to 6 inches in diameter. However, galls produced on leaves seldom develop beyond the size of a pea. They become hard and dry and contain few spores. Galls on leaves do not rupture as do galls on other plant parts. Early infection may kill young seedlings, although this is rare. Plants with galls on the lower part of the stalk may be barren or produce several small ears.

Scouting Procedure/ET

There are no formalized scouting procedures designed to monitor fields for corn smut. Scouts should watch for symptoms of corn smut, or any other disease as fields are scouted for insect pests.

Integrated Control

Non-Chemical Control

Cultural: Control through crop rotation and destruction of individual galls is recommended where feasible. However, the nature of disease dissemination by wind may reduce the effectiveness of rotation. In small garden plots the removal of galls before they rupture may help to reduce the abundance of spores. Avoid mechanical injury to plants during cultivation. Maintain balanced soil fertility and avoid excessive nitrogen or manure. Late applications of 2,4-D plus oil may lead to a higher than normal incidence of smut galls.

Resistant Varieties: Later varieties tend to have less infection than early, small varieties. Plant tolerant hybrids to reduce yield losses from smut infection. Some of these tolerant hybrids include Apache, Aztec, Bellringer, Bodacious, Calico Bell (bicolor), Candy Store (bicolor), Capitan, Challenger, Champ, Cherokee, Comanche, Comet (white), Commander, Crossword (bicolor), Dazzle (bicolor), Epic, Even Sweeter (white), Gold Cup, Golden Gleam, Jubilee, Legend, Melody, Merit, Resister, Seneca Raider, Seneca Star, Stylepak, Sugar Ace, Sweet Belle, Sweet Sal (bicolor), Sweet Sue (bicolor), and Wintergreen.

Chemical Control

None.

Fungicide Resistance: None.

References

Compendium of Corn Diseases. 1973. The American Phytopathological Society, Inc., St. Paul, Minnesota. 64pp.

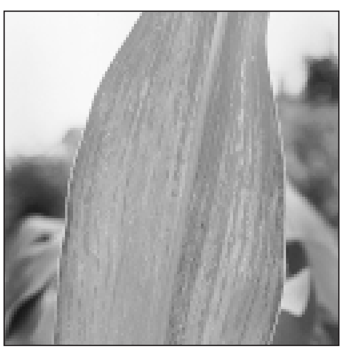
Sherf, A.F. & A.A. MacNab. 1986. Vegetable diseases and their control. John Wiley & Sons, Inc. 728pp.

Ullstrup, A. J. 1978. Corn diseases in the United States and their control. USDA Agriculture Handbook No. 199. 55pp.

Maize Dwarf Mosaic

Cause: Maize Dwarf Mosaic

Type: Virus



General Information

Biological Description:

The organism responsible for maize dwarf mosaic virus is a long, rod-shaped virus which is primarily transmitted by aphids.

Economic Importance:

Many varieties of sweet corn are very susceptible to maize dwarf mosaic (MDM). The virus exists as 6 different strains (MDMV-A, -B, -C, -D, -E, -F) which vary in their host ranges. Plants can be infected with one or more strains at the same time. MDMV-A overwinters in johnsongrass rhizomes in states to the south of Wisconsin. Johnsongrass is not found in Wisconsin, but other perennial grasses are believed to be inoculum reservoirs. The use of resistant varieties is the best control measure for MDM.

Disease Cycle:

Maize Dwarf Mosaic Virus-A and MDMV-B are the most importan strains of MDMVt. MDMV-A is the johnsongrass strain, and it overwinters in johnsongrass rhizomes and other perennial grasses. The overwintering host for MDMV-B, which does not infect johnsongrass, is unknown but most likely overwinters in perennial grasses. MDM was found to be seed transmitted in one variety of sweet corn in less than 1% of the seed; seed transmission of the virus is not important. Both strains of the virus are transmitted by 12 different aphid species. These aphids acquire MDMV-A in the spring from johnsongrass and transmit it to corn when they feed on it. Aphids may transmit other strains of the virus from other possible hosts to corn. Aphids may also play a role in moving MDMV-A from southern areas where johnsongrass is plentiful to northern areas where johnsongrass is not present. During the growing season, aphids spread the virus through the field as they feed on corn plants.

Host Range:

A number of different species of wild and cultivated grasses are susceptible to infection with MDM. The following are some of the most important plants which are susceptible to both strain A and B: sweet corn, dent corn, sugar cane, sorghum, pearl millet, sudan grass, wonder forage grass, tunis grass, guatemala grass, and wild sugar cane. Wild grasses that are hosts for the virus include foxtail, barnyard grass, crabgrass, lovegrass, switch grass, needle grass, wirestem muhli, and two fall panicums. Quackgrass and wild prosso millet are hosts only to strain A; while strain B of the virus does not infect johnsongrass.

Environmental Factors

Factors which favor the development of aphid populations favor the development of virus disease in corn. Mild winters which result in high numbers of overwintering aphids as well as warm temperatures and the lack of severe thunderstorms during the spring, tend to increase aphid populations.

Symptoms

Symptoms first appear at the base of the uppermost, or youngest, leaves as an irregular, striped light and dark green mottle or mosaic. The mottle may develop into narrow streaks along veins that appear as dark green "islands" on a light background. As the diseased leaves mature, they appear to have a finely stippled mosaic of light and dark green. Leaves on certain plants become yellowish-green as they mature. Plants with these symptoms are sometimes stunted because of shortened internodes. Severely infected plants may tiller excessively, have multiple ear shoots, and show poor seed set or may be barren. Symptoms can appear in the field within 30 days after seedling emergence. They are more severe on plants infected early; those infected at silking time or later may appear nearly normal.

Scouting Procedure/ET

There are no formalized scouting procedures designed to monitor fields for virus. Scouts should watch for symptoms of virus infection, or any other foliar disease as fields are scouted for insect pests. Monitoring aphid activity will also provide some insight as to the likelihood of infection.

Integrated Control

Non-Chemical Control

Cultural: Eradicate all johnsongrass and other possible hosts in the field, along fencerows, and in areas adjacent to the field. This will eliminate or reduce the source of MDM infection. Another effective measure for reducing yield losses due to MDM infection is early planting. Aphids that carry MDMV may be windblown from johnsongrass areas.

Resistant Varieties: The most promising way to control MDM is the use of tolerant hybrids. Some of the currently-available varieties of yellow sweet corn resistant to MDMV include Aztec Hybrid, Bellringer, Calumet, Capitan, Enforcer, Florida Staysweet, Guardian, Merit Hybrid, and Seneca 258. Bicolor varieties include Bi-Guard Hyprid, Dandy, and Spring Calico. White-kerneled varieties include Silverette and White Lightening.

Chemical Control

None.

Fungicide Resistance: None.

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Gordon, D. T. 1974. Distinguishing symptoms and latest research findings on corn virus diseases in the United States. 29th Annual Corn and Soybean Research Conference. pp.l53.

Gordon, D. T., J.K. Knoke, and J.D. Farley. October, 1977. 1976: Year of the virus. American Vegetable Grower. pp. 19-20.

McGlohon, N. E. 1972. Corn stunt and maize dwarf mosaic diseases in corn. University of Georgia Extension Service Circular 635.

Muller, G. J. 1973. A compendium of corn diseases. University of Illinois Extension Service Publication. 64pp.

Ullstrup, A. J. 1978. Corn diseases in the United States and their control. USDA Agriculture Handbook No. 199. 55pp.

Rust

Scientific Name: *Puccinia sorghi*

Type: Fungus

General Information:

Biological Description:

Common maize rust is caused by the fungus *Puccinia sorghi*.
Five spore types are produced on two separate hosts.

Economic Importance

Rust may be economically damaging on sweet corn and may result in losses of up to 10%.

Disease Cycle

In tropical regions, the fungus overwinters as teliospores which infect the alternate host, *Oxalis* sp. in the spring. After cross fertilization has occurred, aeciospores are wind-borne to corn. Where the primary infection occurs, symptom expression occurs one to four days after initial infection. Infected corn plants begin to produce urediospores approximately one week after infection. The urediospores are capable of repeatedly infecting corn until late summer at which time the overwintering teliospores are produced. In temperate regions of the United States, infection of the alternate host does not occur. Alternatively, urediospores infect susceptible corn plants directly. These spores are carried northward from the Gulf of Mexico on wind currents. Tracking the northward progression of urediospores is useful in determining when the disease potential is likely to increase.

Host Range
Sweet corn, field corn, and teosinte. The alternate host is *Oxalis*.

Environmental Factors
Temperatures between 60-68°F and high humidity favor infection.

Symptoms
Rust pustules are characterized by elongated, cinnamon lesions located on both the upper and lower leaf surfaces, husks and tassels. Mature pustules rupture to expose the urediospores which are responsible for secondary infection. As the season progresses, and overwintering teliospores are produced the pustules become black. Maize dwarf mosaic virus infected plants are more susceptible to rust.

Scouting Procedure/ET
There are no formalized scouting procedures designed to monitor fields for rust. Scouts should watch for symptoms of rust, or any other foliar disease as fields are scouted for insect pests.

Integrated Control
Non-Chemical Control
Cultural: None.

Resistant Varieties: Resistance provides the primary line of defense against rust infections in sweet corn. Varieties of sweet corn which exhibit some resistance to rust include Athos (bicolor), Calico Bell (bicolor), Flavor King, Flavor Queen, Gemini (bicolor) Kandy Korn EH, Lancelot (bicolor), Melody, Miracle, Seneca Horizon, Sweetie, and Sweetie 82 Hybrid (bicolor)

Chemical Control
Foliar applied fungicides applies early in disease development, may slow disease progression. Registered fungicides include chlorothalonil, maneb and mancozeb. If maneb is used, do not use mancozeb. Preharvest intervals may preclude fungicide use.

Fungicide Resistance: None.

References

Compendium of Corn Diseases. 1973. The American Phytopathological Society, Inc., St. Paul, Minnesota. 64pp.

Sherf, A.F. & A.A. MacNab. 1986. Vegetable diseases and their control. John Wiley & Sons, Inc. 728pp.

Stewart's Disease

Common Names: Stewart's Wilt, Bacterial Wilt

Cause: *Erwinia stewartii*

Type: Bacterium

General Information
Biological Description
Erwinia stewartii is a non-motile, gram-negative rod bacterium. When grown in culture, colonies are yellow and "wet" in appearance. The bacteria may ooze from the cut edges of infected plant tissue.

Economic Importance
Stewart's disease is a widespread disorder in sweet corn. The bacteria that cause the disease spread through the entire plant and can eventually cause plant death. The disease can cause losses of 50-100% on susceptible sweet corn hybrids. The severity of the disease during the growing season may be predicted by the sum of the mean temperatures during the winter months. This actually predicts the survival of the flea beetle vectors.

Disease Cycle
The disease is transmitted from year to year and throughout the season by the corn flea beetle. The causal bacteria overwinter within the bodies of the beetle. When the insects emerge from hibernation in the spring, they feed on corn and thus transmit the bacteria into the plant. The insects are also responsible for the transmission of the disease from infected to healthy plants throughout the summer. Typically, less than 20% of the hibernating beetles are infected. However, by mid-season, this percentage may reach 75%. The bacteria may also be seedborne and this results in disease dissemination over long distances.

Host Range
Erwinia stewartii infects sweet corn, field corn, Teosinte, and eastern gramma grass.

Environmental Factors
The prevalence of Stewart's disease varies from year to year depending on the number of flea beetles that survive the winter. The disease is more prevalent after a mild winter than it is after a severe one. During the growing season, disease severity is increased by high temperatures and dry weather. High levels of soil nitrogen and phosphorus increase the susceptibility of sweet corn to the disease while high levels of calcium and potassium decrease susceptibility.

Symptoms
The first symptoms of the disease are irregular, pale green to yellow streaks that develop on the leaves. These streaks may extend the length of the leaf. The streaked areas, which originate from the feeding wounds of the corn flea beetle, become

straw-colored and usually die quickly. If a leaf is cut in a droplet of water, a yellow bacterial exudate oozes from the vascular bundles. When leaves die prematurely, yield is reduced and the weakened plants become more susceptible to stalk rots. Symptoms of late leaf infections resemble drought or insect injury on the lower leaves of the plant. Plants with stalk rot wilt rapidly and resemble those suffering from drought, insect injury, nutritional deficiency, or seedling blight. Plants that are severely infected develop a chocolate-brown cavity in the lower stalk pith. These cavities can be readily seen when the lower stalk is split lengthwise. Yellow bacterial masses may exude from cut stalks. The entire stalk is stunted, especially if infection occurs early.

Scouting Procedure/ET

A forecasting system has been developed to predict the severity of Stewart's disease. It is based on the sum of the average mean temperatures during December, January and February. This forecasting system actually predicts the winter survival of the corn flea beetle.

Total Mean Temperatures	Predicted Wilt Severity	Predicted Leaf Blight Severity
80-85 degreesF	none-light	none-light
85-90 degrees F	light-moderate	light-moderate
90-95 degrees F	moderate-severe	moderate-severe
>95 degrees F	severe	severe

Integrated Control

Non-Chemical Control

Cultural Control: Plant disease-free seed which has been grown in areas where Stewart's disease is not a problem. Do not apply fertilizers that lead to unusually high nitrogen or phosphorus content. Adequate levels of potassium and calcium are necessary to minimize the disease prevalence.

Resistant Varieties: Effective control may be achieved by planting resistant or tolerant varieties of sweet corn. Some of the resistant hybrids include Alpine, Pearl White, Silver Queen Hybrid, and Silverado.

Chemical Control

Early spraying of dusting of plants with insecticide to kill flea beetles is effective in reducing the initial infections and spread of the disease.

Fungicide Resistance: None.

References

Compendium of Corn Diseases. 1973. The American Phytopathological Society, Inc., St. Paul, Minnesota. 64pp.

Sherf, A.F. & A.A. MacNab. 1986. Vegetable diseases and their control. John Wiley & Sons, Inc. 728pp.

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UW Extension

The Natural Enemies of Insect and Mite Pests

Daniel L. Mahr, Department of Entomology, University of Wisconsin–Madison

Biological control is the active utilization of beneficial living organisms to control pests. The beneficial organisms we use are usually referred to as "natural enemies" of the pests, and are placed in three broad groups: predatory insects, parasitic insects, and insect pathogens. In the upper Midwest, literally hundreds of types of natural enemies occur naturally in the environments of agricultural crops, managed forests, and managed urban and suburban landscapes. These have a very major impact on pest populations, and often result in keeping pests below damaging levels. When there is no human activity involved in managing these natural enemies, we refer to the results as "natural control" of the pests. Natural control is of major importance in pest management, but the benefits frequently go unrecognized because the natural enemies are often very small and their activity is easily overlooked.

In order to get the greatest benefit from both natural control and biological control, it is necessary to recognize natural enemies, understand their biological characteristics (such as life cycle, preferred host insects, and efficiency at controlling pests). Some natural enemies, such as lady beetles, are readily recognized in the adult stage by most people, but may not be recognized in the egg, larval, or pupal stages. Other natural enemies, including most parasites, are much more difficult to recognize.

Although birds, mammals, frogs, and other higher animals can be important as natural enemies, they can rarely be effectively managed for biological control. These animals lie outside the scope of this discussion, which deals primarily with the insects which are predators or parasites of pest insects and mites.

Predatory and Parasitic Insects

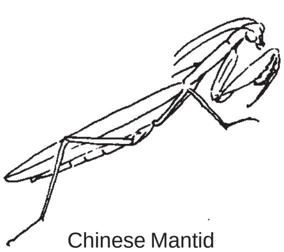
There is a very large number of different types of predatory and parasitic insects. A standard reference book about insects lists a total of 328 families. Between one third and one half of these families contain species that are predaceous or parasitic on other insects. Many of these families, however, are of little or no consequence to agriculture. For example, there are seven families of dragonflies. All species of dragonflies are predaceous on small insects, capturing them in flight, and are important regulators of population numbers of small insects such as gnats, midges, and mosquitoes. However, the diet of dragonflies does not usually contain a significant number of agricultural pests. Therefore, a smaller number of families consist of important natural enemies of agricultural pests, and these are the ones that will be covered.

The Praying Mantids (Order Mantodea)

Praying mantids are all predatory on other insects. They have highly modified and strengthened front legs for capturing and subduing their prey, and they have chewing mouthparts. Large mantids can inflict a painful bite if handled. They all belong to the family Mantidae.

Family Mantidae: The Praying Mantids

Mantids are among the most recognizable of predaceous insects. These are often thought to be highly beneficial, an assumption furthered by their sales through ads in gardening magazines. Mantids are highly predaceous, and not directly damaging to plants. However, they are opportunistic feeders, consuming whatever comes into their grasp, including other natural enemies, pollinators such as honey bees, and completely innocuous insects, as well as occasional pests. They are cannibalistic and will readily consume each other.



Chinese Mantid

Mantids are not native to areas of extreme winters, and can not naturally be found in Wisconsin. Those that are introduced, such as from commercial suppliers, will not survive northern winters. In more southerly states where they do occur naturally, they are rarely found in abundance, a situation partially attributable to their cannibalistic nature.

Mantids have only a single generation per year, and overwinter as eggs in cases which contain from several dozen to several hundred eggs. It is in this form that they are distributed commercially. These purchased egg cases are distributed outdoors to hatch and populate the area through natural movements of the young. Because of their cannibalistic behavior and their rapid dispersal to avoid cannibalism, rarely can more than one or two be found in the vicinity of the original egg case. This in combination with their indiscriminate predation on beneficial and innocuous insects as well as pests, renders them virtually useless as effective natural enemies of garden or crop pests.

The True Bugs (Order Hemiptera)

All of the true bugs undergo simple metamorphosis, meaning that the immature stages (called nymphs) look like small, wingless versions of the adults. All have piercing-sucking mouthparts, meaning that they suck body fluids from their prey rather than chewing it up. Some Hemiptera are serious crop pests and others (such as bed bugs) are pests of human health and livestock. Some predatory Hemiptera can inflict painful a bite if mishandled, sometimes resulting in severe inflammation of the area surrounding the bite, which may persist for several days.

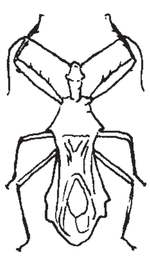
In all predatory Hemiptera, both the nymphs and the adults are predaceous, and often can be found in the same general habitat feeding on similar types of insects, although the young nymphs usually require smaller prey. Some predaceous Hemiptera feed to a small extent on plants, sucking plant sap, but there are no indications that this causes plant damage.


Minute Pirate Bug

Family Anthocoridae: The Pirate Bugs

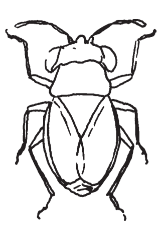
These are tiny insects, only 1-2 mm in size. Nymphs and adults feed on mites, small insects, and eggs. They are very common in many agricultural situations, especially where broad-spectrum insecticides are not routinely used, and are considered to be very beneficial general predators.

Orius insidiosus, the minute pirate bug is probably the most important species in our region. It is an important predator of thrips, aphids, and spider mites on many crops. It is also an important predator of insect eggs. It is considered to be one of the more important natural enemies of corn earworm, and can destroy 50% or more of the eggs of this pest. Both the young and adults of *Orius* can consume 30 or more spider mites per day.


Assasin Bug

Family Reduviidae: The Assassin Bugs

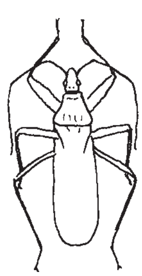
Some assassin bugs are parasitic bloodsuckers of mammals and have been implicated with the transmission of serious human illnesses. However, most species are highly beneficial predators of many serious crop pests. These are medium sized bugs (up to about 1 inch long) and can subdue and kill medium sized caterpillars and similar insects. They are generalist predators frequently found in gardens and fields.


Geocoris

Family Lygaeidae: The Seed Bugs and Bigeyed bugs

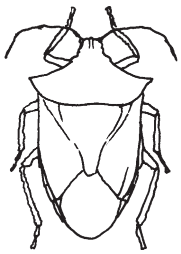
This family consists of both plant-feeding insects as well as predators. Many of the plant feeders feed specifically on fruits or seeds, hence the common name. The bigeyed bugs occur in the genus *Geocoris*. These are very beneficial predators which occur in many habitats and feed on many types of prey. *Geocoris punctipes* has been noted to feed on as many as 1600 spider mites during the course of its nymphal development, and an additional 80 mites per day as an adult.

Bigeyed bugs are found in many agricultural situations, especially where broad spectrum insecticide use is minimal, and in many non-crop situations. For example, bigeyed bugs are commonly found in lawn grass, where they are felt to be important predators of chinch bugs, greenbugs, sod webworms, and other turfgrass pests.


Damsel Bug

Family Nabidae: The Damsel Bugs

This is a small family of general predators commonly found in many crop and garden situations. Adults are 1/3-1/2 inch in length and slender-bodied. The tan colored *Nabis ferus* is a common species in our region. It feeds on many types of insects, ranging from leafhoppers to small caterpillars. Some other species of damsel bugs are black in color.



Stink Bug

Family Pentatomidae: The Stink Bugs

Stink bugs are medium-sized insects with a broad, shield-shaped body. They are usually green or brown, but sometimes brightly colored. Many discharge a disagreeable odor, especially when handled, hence their common name. Many are plant feeders and some of these are serious pests on a variety of crops. However, some species, especially in the genera *Podisus* and *Perillus*, are important predators. *Podisus maculiventris* and *Perillus bioculatus* both feed on caterpillars and larvae of leaf-feeding beetles such as Colorado potato beetle and Mexican bean beetle. These are highly efficient predators capable of consuming many prey during the course of their development. *Podisus* has two generations per year and each female can give rise to 1000 or more offspring. The eggs are laid in clusters on leaves. The young are small and round. The youngest nymphs of some predatory pentatomids may feed to a limited extent on leaf sap, but such feeding is not damaging.

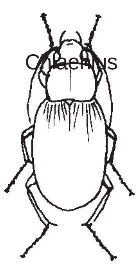
The Beetles (Order Coleoptera)

The order Coleoptera is the largest group of insects in the world, constituting about 40% of all known insect species. There are about 30,000 species in the United States. The habits of this group vary considerably; many are aquatic, many are found in the soil, some are parasitic, and many are free-living. Many are plant feeders and some are serious pests. Some feed on fungi or are scavengers. Many are predators of other insects.

All beetles undergo complete metamorphosis, meaning that the immatures look nothing like the adults; instead they are worm-like or grub-like. Insects with this type of development also have an extra transitional stage, the pupa, between the last larval stage and the winged adult. Therefore, these types of insects have egg, larval, pupal, and adult stages. Depending on the species, larvae and adults may do similar or very different things. For example, both the adults and larvae of lady beetles are predatory, usually on the same types of prey. However, while blister beetle larvae are parasitic on grasshopper eggs and ground-nesting bees, the adults are generally plant-feeders.

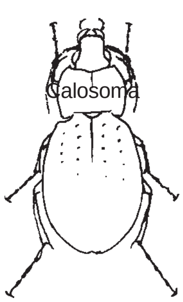
Approximately 40 families of beetles are known to have predatory or parasitic members. In some families, insect feeding may be only incidental, while in other families it is the rule. By far, the two families most important in crop protection are the predaceous ground beetles (family Carabidae) and the lady beetles (family Coccinellidae).

Family Carabidae: The Ground Beetles



Chlaenius

Other than a few isolated cases, the benefits of this large family have not been well studied. This relates primarily to their hidden habits of living in or on the soil and being active primarily at night, two situations which makes study difficult. Ground beetles vary in size from a few millimeters to over an inch in length. Most species are brown or black, but a few are metallic blue or green. There is generally one generation per year, but the adults of larger species are known to live 2-4 years. The larvae of some species may require more than one year to complete development. Carabids can be found in most agricultural and garden settings. Most species which have been studied are predaceous as both larvae and adults, although some are scavengers and a few feed on plants. The predatory species feed on insects found in or on the soil, earthworms, and similar small invertebrate animals. Many insects, even leaf feeding insects, spend part of their life cycle in the soil or under leaf litter, especially to pass the pupal stage or to overwinter. Such insects often suffer a high degree of natural mortality at such times, and several studies have shown that ground beetles are important in such mortality.

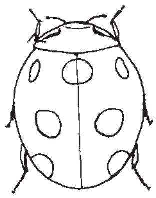


Calosoma

A few ground beetles are found in trees and shrubs where they prey on other insects found in these habitats. Members of the genus *Calosoma*, which occurs both in the United States and Europe, are referred to as caterpillar hunters because they are voracious predators of caterpillars. The adult beetles are amongst the largest in the family, and both adults and larvae are very active predators. *C. sycophanta* is a large metallic green species introduced into the United States from Europe for control of gypsy moth. Studies have shown that *Calosoma* larvae will consume as many as 40 large gypsy moth larvae, while adults can kill as many as 200 or more.

Family Coccinellidae: The Lady Beetles or Ladybirds.

Although frequently called "ladybugs", these insects are not true bugs and therefore the other common names are preferred.

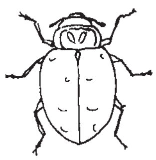


Ladybird Beetle

It should be noted that the first successful case in modern biological control involved the importation from Australia and New Zealand of the vedalia beetle, a lady beetle, for controlling cottony cushion scale in California citrus groves. This occurred in 1889.

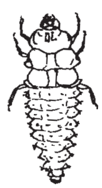
The lady beetles are a large group containing many important natural enemies. Although most are predaceous as both larvae and adults, a few are fungus feeders and a few feed on plants, including a couple of important pest species such as the Mexican bean beetle.

Predaceous lady beetles feed primarily on aphids, scale insects, mealybugs, and whiteflies. One group, the genus *Stethorus*, contains small lady beetles that are important predators of spider mites on tree fruits and other crops. There are specialized lady beetles that limit their feeding to other prey groups, such as small caterpillars and leaf beetle larvae. Although most common species feed primarily on aphids and similar insects, other types of prey will occasionally be taken. Spider mites can be an important supplemental prey of many species of aphid-feeding coccinellids. Adult lady beetles also tend to feed on nectar and pollen taken from flowers.



Hippodamia

Lady beetles overwinter in the adult beetle stage. Some species, such as our native convergent lady beetle, *Hippodamia convergens*, are known to congregate in enormous clusters. Other species overwinter singly or in small clusters. In spring they seek out the aphids or other hosts that will be both adult and larval food. Eggs are laid adjacent to the prey. Many deposit spindle-shaped eggs, laid on end on the leaf surface. Some species scatter individual eggs while other species lay in compact clusters of 10-20 or more. The eggs of the aphid-feeding species are usually yellow to orange in color, and 1-1.5 mm long. Eggs usually hatch in 3-7 days.



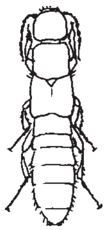
Larva

Lady beetle larvae are not as frequently recognized as are the adults, an unfortunate circumstance because they are just as important as the adults in natural control. The larvae of the aphid-feeding species are somewhat slender, with the body tapering to a point at the rear. Depending on species and stage of development, they will be 1/8-1/2 inch in length. The color is usually black or dark gray, but there usually are conspicuous, red, yellow, orange, or blue markings. The prominent legs are held to the side. The predators of mealybugs and scale insects may not be as conspicuous, as they are often covered in a white waxy coating similar to that of the prey insects. Larval lady beetles normally consume 500-1000 aphids or similar prey during their growth.

Pupa

If prey are abundant and temperatures warm, most lady beetle larvae complete development 2-4 weeks after egg hatch. When done feeding, the larvae pupate in the same location. The pupal stage also is unrecognized by most people. The pupal period lasts about one week. Therefore, the entire life cycle takes about 4-6 weeks. Generally, there are two to three generations per year, more in warmer areas with longer growing seasons.

There are many species of beneficial lady beetles in the North Central United States, and only a few brief examples can be discussed here. The convergent lady beetle is one of the most common throughout the United States, and is a very important predator of aphids and other pests. Recently, a large lady beetle from Europe was introduced into the United States for aphid control. *Coccinella septempunctata*, sometimes called C-7 (derived from the scientific name), has rapidly become established and spread throughout much of the region. It is very noticeable because of its large size. The multicolored Asian lady beetle, *Harmonia axyridis*, is another introduced species. It is a specialized predator of aphids infesting trees such as fruit trees. It tends to congregate near buildings in the fall of the year and can sometimes be a bit of a nuisance. This is another reddish orange lady beetle, but the pattern and number of black dots of this species are variable; indeed, some have no black dots at all. Members of the genus *Stethorus* are only a few millimeters long and black in color, and therefore not very conspicuous. As both larvae and adults, these are important predators of spider mites, and are capable of consuming many mites during their lives. The mealybug destroyer, *Cryptolaemus montrouzieri*, was introduced into the United States for controlling mealybugs on citrus and other crops. Although it does not survive winters in most of the United States, it is under commercial production and can be purchased for periodic colonization. The twicestabbed lady beetle is small and shiny black, with a bright red spot on either side of its body, hence the name. It is an important predator of scale insects and other pests, and is frequently seen in association with cottony maple scale and undoubtedly is important in control of this pest of silver maples.


Rove Beetle

Family Staphylindae: The Rove Beetles

This is the largest family of North American beetles, with about 2900 species. Most are quite small and of cryptic habits and the group as a whole is not well studied. Most are thought to be predaceous, although many are probably scavengers. Although these are small insects, usually less than ¼ inch in length, they are quite recognizable because of their slender, usually black body, shortened front wings (elytra), and behavior of curling the tip of the abdomen upwards when disturbed or running.

Most rove beetles are found in association with soil or decaying organic matter. Many are predaceous or parasitic and undoubtedly help reduce populations of filth flies. Several occur in agricultural soils where they probably feed on a variety of types of prey. A few species can be found in vegetation where they feed on many types of small insects.

Lacewings, Antlions, and Others (Order Neuroptera)

The order Neuroptera contains several small families, most of which are predaceous or parasitic as larvae and predaceous as adults. Members of several families are quite uncommon, and other families, such as the antlions and snakeflies are more common in the South and West than here in the upper Midwest. Most families provide no appreciable benefit to agriculture, but two families of lacewings are quite important.

Family Chrysopidae: Green or Common Lacewings

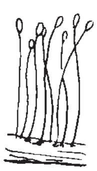
Green lacewings are common throughout the United States and are frequently found in fields, orchards, and gardens. Both adults and larvae are important predators of aphids and other small insects. The adults, which are often attracted to lights at night, have pale green bodies about 1 inch long, large, clear, membranous wings with green veins and margins, and long hair-like antennae; the eyes are often golden and the body is slender and soft. The most commonly seen species are in the genus *Chrysoperla*.


Green Lacewing

The oval, white or greenish eggs are readily recognized because each is attached to a slender hairlike upright stalk, usually about 1/3 inch in length. Although most species lay their eggs singly, some lay their eggs in clusters. The eggs are usually laid on foliage near colonies of aphids or other prey. The eggs hatch into small, gray, slender larvae that are called aphidlions. These larvae have enlarged sickle-shaped mouthparts used to puncture the prey and suck out the internal fluids. The larva ultimately grows to about ½ inch in length and then spins a spherical silken cocoon, usually on the underside of a leaf, within which it pupates. The entire development period is about one month, and there can be from one to several generations per year, depending on species and location.


Larva

Green lacewings are highly beneficial insects found in many types of crop and garden situations. They are also raised in commercial insectaries and can be purchased for biological control. Usually it is the egg stage that is sold.


Eggs

Family Hemerobiidae: Brown Lacewings

These are similar to green lacewings in general appearance, but are brown in color and smaller. The eggs are not stalked as in green lacewings. Brown lacewings occur both in field and forest situations, but are not as common in agriculture as are chrysopids. Both larvae and adults feed on aphids and other small, soft bodied insects.

Flies, Gnats, Midges, and Others (Order Diptera)

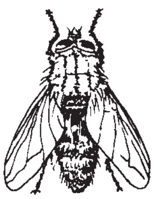
The flies constitute one of the largest groups of insects, and they are very diverse in their habits and habitats. Approximately 35 families are known to contain species that are predatory or parasitic on other insects. Some of these occur primarily in aquatic or semiaquatic environments where they feed on other insects in those areas, including mosquitoes, black flies, and other public health or nuisance pests. Only those families that are commonly encountered or important in pest management are discussed here.

Family Syrphidae: The Hover Flies

Syrphid Fly

This is a large family of common insects. The adult flies are small to medium in size, with the body often striped yellow and black: some resemble bees or wasps. They are often seen on or hovering near flowers, and the adult flies feed exclusively on flower nectar and pollen. Although the biological habits of the larvae are quite diverse, many are predaceous on aphids, scale insects, and other insects. The aphid predators are quite common. These pale green to yellow maggots have a slug-like appearance and the larger species attain a size up to ½ inch in length. Some studies indicate that as many as 400 aphids are consumed during larval development. In some cases pupation occurs on the foliage near the feeding site but some fully developed larvae will leave the plant and enter the soil to pupate. The puparium is often tear-drop shaped. The life cycle of species studied takes two to four weeks to complete.

Family Sarcophagidae: The Flesh Flies



Flesh Fly

This is a large family of medium to large sized flies. They somewhat resemble house flies, but are often gray and black striped and distinctly bristly. When they occur in numbers they can be a significant nuisance because of their persistent droning and inclination to land on food and people. The larval habits are diverse, with some species breeding in carrion and others being parasitic on higher animals. Many species, however, are specialized parasites of other insects. Of the parasitic species, the largest group of hosts are the grasshoppers, and both nymphs and adults can be parasitized. Hosts of other sarcophagids include larval and adult bees (including the honey bee and bumble bees), beetles, and caterpillars. One of the most common insect-parasitic sarcophagids in the northern United States attacks the forest tent caterpillar. During outbreaks of the host insect, this large fly occurs in abundance, and is considered by local residents as a nuisance. However, it provides significant control of the pest.

Family Tachinidae: The Tachinid Flies

Tachnid Fly (a)

Tachnid Fly (a)

This family is by far the largest and most important group of flies, with over 1300 species in North America. All species are parasitic in the larval stage, and many are important natural enemies of major pests. Many species of tachinids have been introduced into North America from their native lands to suppress populations of alien pests. Tachinid flies are variable in color, size, and shape, but many are somewhat reminiscent of house flies. They usually are house fly shaped, either gray, black, or striped, and often with many distinct abdominal bristles.

Tachinids are usually fairly host-specific, and, as a family, most frequently attack caterpillars and adult and larval beetles. Sawfly larvae, various types of true bugs, grasshoppers, and other types of insects are also attacked. The life cycles of many tachinids have been studied in some detail, but only generalities for the family can be given here. Egg formation and oviposition varies considerably. In some species, eggs are deposited on foliage or other substrate near the host. In other species, the eggs are glued to the body of the host, and sometimes conspicuous white eggs up to 1 mm in size can be found on the head or body of a caterpillar or other host. After the eggs hatch, the maggots penetrate into the host's body. Some adult female tachinids possess a piercing ovipositor and actually insert the eggs inside the host body. Many tachinids exhibit an unusual trait in which the eggs mature within the mother fly, which then lays eggs that immediately hatch. In some species, egg hatching actually occurs within the mother fly, and she gives birth to living young, a behavior called "larviposition". Egg and larval development are rapid for most tachinids, and pupation often occurs within 4-14 days after oviposition. The pupal period generally lasts 1-2 weeks. Many species are capable of several generations per year, but others are restricted to only one generation, especially if their hosts have only a single generation. Most, if not all, tachinids are internal parasites within their hosts. Most species are solitary, but some are gregarious, with anywhere from 2-3 up to a dozen or more capable of developing from a single host.

Wasps, Ants, and Bees (Order Hymenoptera)

The order Hymenoptera is divided into two suborders. The smaller consists of the sawflies and horntails. Most of these are plant feeders and many are serious pests of agricultural and horticultural plants and forest trees. The larger group consists of the bees, wasps, and ants. There are several families of bees, and all feed primarily on nectar and honey. The ants are in a single family (Formicidae) of diverse habits, but many species are predaceous on other insects, and some are very important in natural control. The wasps are a very diverse group of over 50 families, most of which feed entirely on other insects. The Hymenoptera is the second largest group of insects. Over 16,000 species are known from the United States and Canada; the majority of species are parasitic on other insects. Many of the parasitic species are very tiny and easily overlooked. These are commonly called "microhymenoptera", and, because of their small size (as small as 0.5 mm, or 1/50 inch), many are as yet unknown to science.

As an order, the Hymenoptera are the most beneficial of all groups of insects. Bees provide honey and wax, and pollinate our crops. The parasitic wasps are the most important group of natural enemies of pest insects. Many different species have been transported around the world for control of alien pests, and several species are commercially available for the control of specific hosts.

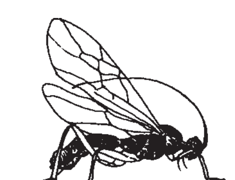
All Hymenoptera undergo complete metamorphosis, having egg, larval, pupal, and adult stages. The most important natural enemies are the many families of parasitic wasps, or "parasites". In these the larval stage develops in and kills a single host insect. Some adult parasites also feed on insects, usually the same species which are host to the larval stage; this behavior is called "host feeding". Although it may seem inefficient that each larva kills only one host insect, most adult parasites have a very high reproductive capacity, and usually individual females can lay many hundreds of eggs, resulting in the death of an equal number of host insects.
By being able to reproduce so rapidly, they efficiently overtake increasing host populations and therefore often are able to suppress pests below injury levels.

The behavior of parasitic Hymenoptera is quite complex. Many are highly selective to a single species of host insect, or a narrow range of related hosts. The adult females often have highly developed means of locating the hosts that they will parasitize. This searching ability is important because it means that adult female wasps can locate and parasitize hosts at low host densities, another important factor in keeping pest populations low.

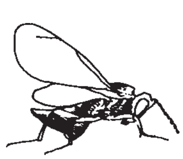
The hosts of the parasitic Hymenoptera are diverse and include almost all groups of terrestrial insects. The important agricultural groups such as caterpillars, beetles, sawflies, aphids, and scale insects are frequent hosts. Depending on the parasite species, virtually any host stage can be attacked: egg, nymph, larva, pupa, or adult.

Although we have thus far discussed primarily the parasitic wasps which, because of their small size are frequently overlooked, many of the larger wasps that are more frequently recognized because of their bright colors and ability to sting, also kill other insects. These larger wasps usually develop a cell of some sort for their larvae and provision these cells with food. In the predatory species the adults forage for insect prey to take back to the cell to feed the young. Many of the larger wasps are social insects and some can have quite large colonies.

Cryptus



Rogas



Pteromalid

Family Ichneumonidae: Ichneumon Wasps

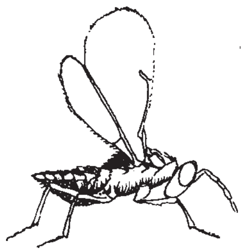
This is one of the largest families of insects. All species are parasitic on other insects. As a group ichneumonid wasps are larger in size than many other parasitic wasps. They parasitize a variety of insects in several insect orders, but the Lepidoptera (moths and butterflies) and Coleoptera (beetles) contain the largest numbers of hosts. Many ichneumonid females have elongate, very noticeable ovipositors.

Family Braconidae: Braconid Wasps

Another large group, closely related to the ichneumonids, the braconids also are exclusively parasitic. Many are very important parasites of major agricultural pests, such as caterpillars, various beetles, aphids, fly maggots and other insects.

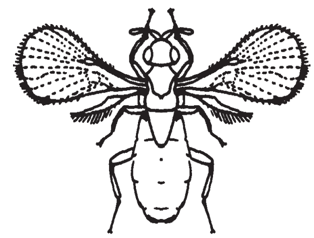
Superfamily Chalcidoidea: The Chalcid Wasps

This is actually an assemblage of several specialized families. Most species are insect parasites but a few, such as alfalfa seed chalcid, are plant pests. Most all are quite tiny insects and attack fairly small hosts. Aphids, scale insects, fly larvae, leafminer larvae, small caterpillars, and many other types of insects are attacked by chalcids. Some chalcids are so tiny they complete their entire life cycle in the egg stage of their host insect. This is true of all species of the families Mymaridae and Trichogrammatidae. *Trichogramma* species attack the eggs of many types of serious pests, especially caterpillars. *Trichogramma* are commercially mass produced and are widely used in biological control programs in Europe and Asia, and to a lesser degree in the United States.



Eulophid

Dolichometus



Trichogrammatid

Scouting Natural Enemies in IPM Monitoring Programs

Because natural enemies are so important in helping control pest populations, it's pretty obvious that we should not be making pest control decisions based exclusively on the population levels of the pests without also considering the activities of their natural enemies. In some cases, action decisions have been developed based on pest population levels, but also on the ratios between the pest and its natural enemies. For example in apples, when scouting for the leaf pest European red mite, we also count the number of predatory mites that are present; the decision of whether or not to spray is based on both the numbers of the pest as well as the ratio between pest and natural enemies. Unfortunately, there are relatively few cases where sufficient research has been conducted to develop decision-making guidelines on such a quantitative basis. Still, there are things that can be done to take advantage of the benefits of natural enemies.

1. Recognize the important pests that attack a crop. Keep in mind that if you see insects that are unfamiliar, they are not necessarily pests. They may actually be beneficial. If in doubt, contact someone who can help you. The Insect Diagnostic Lab in the Department of Entomology at UW-Madison will identify questionable insects. There is no charge for this service, and the samples may be submitted by taking them to your local county UW Extension office.
2. Learn to recognize important groups of natural enemies, so that when you see these in the field you understand that they are beneficial. When you see natural enemies, briefly observe them to see if they are preying on pests. Also learn to recognize the signs of natural enemy activity, such as aphid mummies, parasite pupae associated with the dead remains of a pest, and insects killed by disease.
3. If possible, also learn to recognize the specific natural enemies of the specific pests of concern. For example, the pupae of parasites of alfalfa weevil and imported cabbageworm are very distinctive.
4. While scouting pests, scout natural enemies also. The numbers of both pests and natural enemies should be recorded from week to week. For example, if aphid populations are declining while predator populations are increasing, this information may influence pest management strategies.

In summary, both natural control and biological control are important in insect and mite pest management. However, to achieve maximum benefit from natural enemies, you need to be able to recognize them and know a bit about their biological characteristics.

Contents Weed Guide (WG)

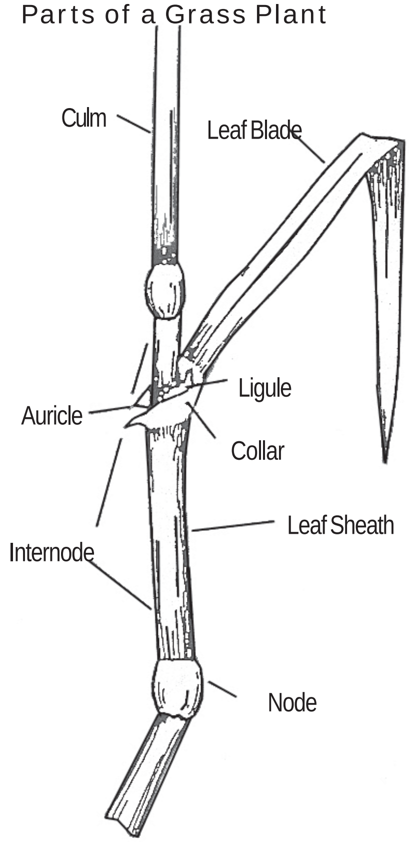
Weed Identification Section

Herbicide Injury Section

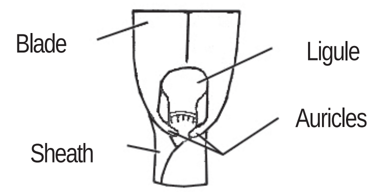
Monocot
Weed Seedling Identification Key

Monocot seedling identification can be challenging. Careful attention to detail is required. Check the drawings for key terms and structures that you need to know to successfully identify plants in this group. Then examine the leaf collar, leaf blade, leaf sheath and shoot of the weed in question and follow the key on the next page.

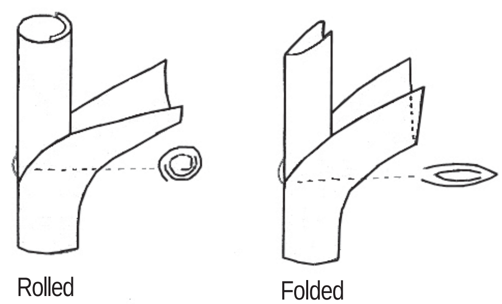
Parts of a Grass Plant



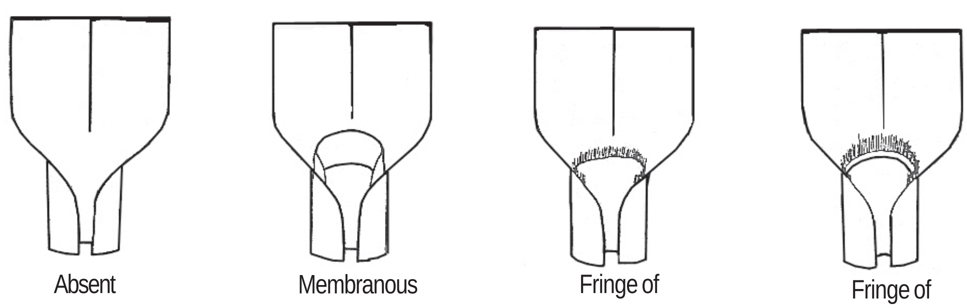
Terminology of Grass



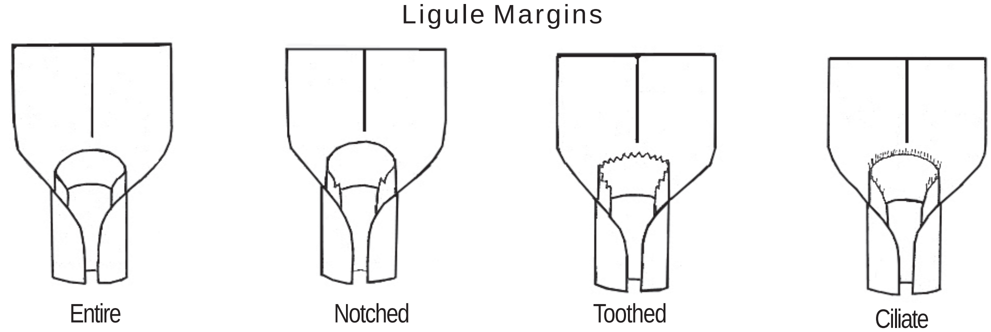
Leaf Arrangement in Young



Ligule Types



Ligule Margins



Monocot Weed Identification Key

Grass and grass-like weeds pose some of the greatest challenges in weed identification. Accurate identification, even at the difficult seedling stage, is however crucial to formulating a successful weed management strategy. Although this key is not all inclusive (it covers 14 grasses and 1 sedge), these are the grasses which predominate Wisconsin agriculture. To use this key, begin by determining the absence or presence of a ligule (diagrams defining identification terminology can be found on the back side of this page), checking for hairs on the leaf blade and sheath, and then determining if any of the confirming traits are present. This key is meant to be a quick and concise identification tool. If you are left with any question concerning the identification of a weed, consult one of the many in-depth weed identification guides readily available today.

Ligule	Hairs present on: Blade	Sheath	Confirming Traits	The Weed Is…
none	no	no	Triangular stems, 3-ranked waxy leaves, tubers at end of rhizomes	**Yellow Nutsedge**
none	no	no	Stem sharply flattened, leaf collar yellowish	**Barnyardgrass**
hairy	long wiry hairs at base of blade	no	Stem flattened, cylindrical seed heads with yellowish awns	**Yellow Foxtail**
hairy	no	occasionally on sheath margin	Stem flattened with purplish bases, common on sandy soils, twisted leaves & spiny fruit	**Sandbur**
hairy	no	margin – yes surface – rarely	Seed head tapers at tip, purple & white biotypes exist (rare)	**Green Foxtail**
hairy	short hairs on entire upper surface	margin – yes surface – rarely	Large drooping seedheads	**Giant Foxtail**
hairy	few hairs on blade near ligule	sheaths of first tillers hairy	Prominent midrib white on older plants, stem bases often purplish	**Fall Panicum**
hairy	very hairy upper and lower surface	covered with bristly hairs	Rounded stems, open panicle seed head with very small seeds	**Witchgrass**
hairy	some hairs on both leaf surfaces	covered with bristly hairs	Tan to black shiny seeds, often attached to root	**Wild Proso Millet**
hairy	short hairs on both upper & lower surface	covered with short, fine hairs	First leaf relatively wide, 90^0 to stem, stem nodes swollen, one leaf margin often wrinkled	**Woolly Cupgrass**
membranous (very short)	no	sheaths hairy in spring	Whitish-yellow leaf collar with clasping auricles, long rhizomes	**Quackgrass**
membranous	no	no	Jagged ligule, wire-like stems with narrow leaves, short scaly rhizomes, plant appears bushy	**Wirestem Muhly**
membranous	yes	yes	Flattened stems, low spreading growth, roots at nodes	**Large Crabgrass**
membranous	sparse if present	sparse if present	Lighter green, smaller and less hairy than large crabgrass	**Smooth Crabgrass**
membranous initially (hairy later)	no	no	Stems round, leaf blades wide, large black & shiny seeds often attached to root	**Shattercane**

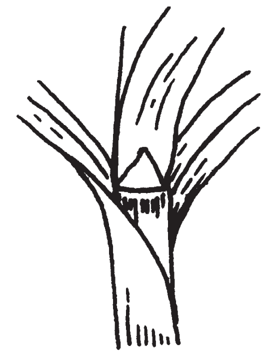
D.J. Heider. University of Wisconsin Integrated Pest Management Program

Identification of Common Wisconsin Weeds

Annual & Perennial Monocots

SEDGE FAMILY

Yellow nutsedge (44)



stems: triangular, nodeless and solid

leaves: 3-ranked, shiny and waxy; basal and involucral

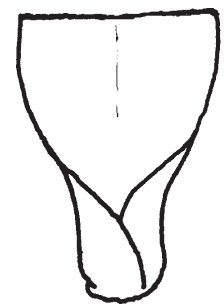
flowers: small, yellowish to yellowish-brown

rhizomes: 4" - 12" long tubers formed at the end of rhizomes

other: seeds brownish, 3 sided; perennial

GRASS Family

Barnyardgrass (23)



stems: flattened; base often purplish

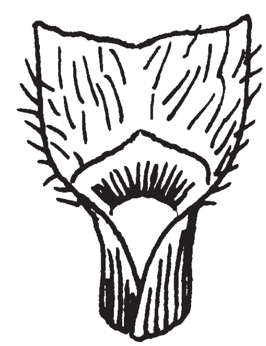
leaves: smooth; occasionally few hairs in leaf collar area

ligule: absent

other: seed head has awns that vary in length

GRASS FAMILY

Yellow foxtail (36)



stems: flattened; base often reddish

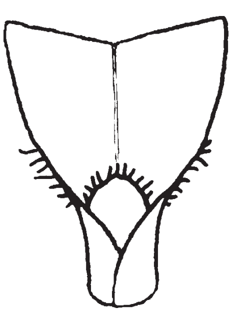
leaves: long hairs on upper surface at base of blade

ligule: hairy

other: seed head is yellowish color, bristly, cylindrical and erect

GRASS FAMILY

Sandbur (20)



stems: flattened; base often reddish

leaves: smooth, twisted

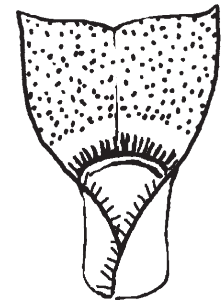
ligule: hairy

other: found mostly on sandy soil; fruit a spiny bur

Numbers in parentheses denote pages in *Weeds of the North Central States* that describe the weed.

Annual & Perennial Monocots

GRASS FAMILY
Giant foxtail (35)



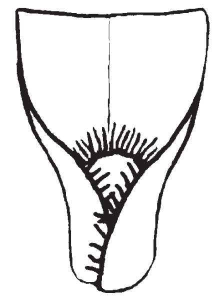
stems: rounded to slightly flat

leaves: short hairs on upper surface only; hairy sheath margin

ligule: hairy

other: seed head is large and drooping

GRASS FAMILY
Green foxtail (38)



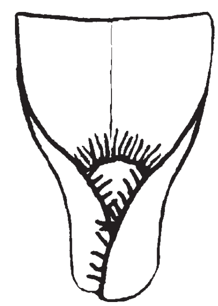
stems: rounded to flattened

leaves: no hairs on blade; hairy sheath margin

ligule: hairy

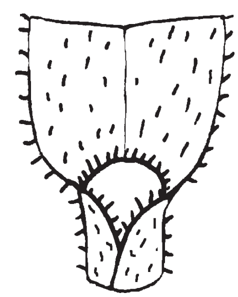
other: seed head usually smaller than giant foxtail; larger at base and tapering at tip.

GRASS FAMILY
Green/white robust foxtail (38)



Plants usually larger than green foxtail; no hair on blade; large, drooping seedheads with purple or white bristles

GRASS FAMILY
Witchgrass (31)



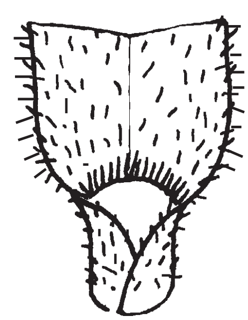
stems: rounded; semi-decumbent

leaves: sheath and blade very hairy

ligule: hairy

other: seed head on open panicle with very small seeds

GRASS FAMILY
Wild proso millet (33)



stems: rounded, with many tillers

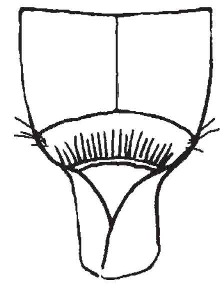
leaves: hairy blades, always on top, sometimes below; sheath always bristly hairy

ligule: hairy

other: relatively large tan to black shiny seeds

Annual & Perennial Monocots

GRASS FAMILY
Fall panicum (32)



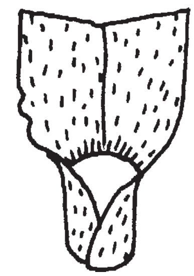
stems: rounded, with a reddish-purple base

leaves: first leaf swaths hairy; later smooth; sheath margin smooth; few hairs at blade base; prominent midrib

ligule: hairy

other: seeds smaller than wild proso millet

GRASS FAMILY
Woolly cupgrass (26)



stems: rounded stems with swollen nodes

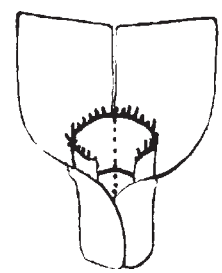
leaves: blades & sheath finely pubescent; blade wrinkled on one edge

ligule: hairy, short

seeds: large straw-colored seeds

seed head: composed of several branches *(rachis)*

GRASS FAMILY
Shattercane (39)



stems: rounded, large and with many tillers

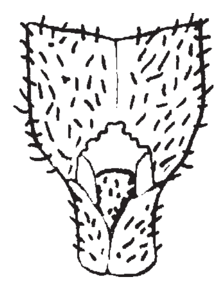
leaves: sorghum-like; white midrib above and prominent below

ligule: membranous with hairs on top by midseason

seed head and seeds: panicle inflorescence, a panicle; relatively large black, shiny seeds

other: grows 4-8 feet tall; if rhimomes found, it is sorghum almum

GRASS FAMILY
Large Crabgrass (22)



stems: rounded to flattened, decumbent and branched

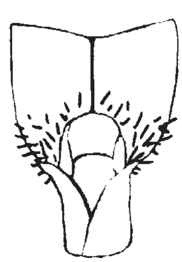
ligule: membranous

leaves: sheath & blade hairy

seedhead: a branched finger-like structure; seeds flattened against branches

other: roots often form at nodes

GRASS FAMILY
Smooth Crabgrass (22)

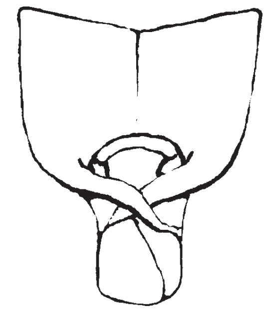


Similar to large crabgrass but few if any hairs on leaf sheath and blade;

smaller; lighter green color

GRASS FAMILY

Quackgrass (14)



stems: rounded

leaves: sheath hairy early

ligule: membranous; very short and hard to see

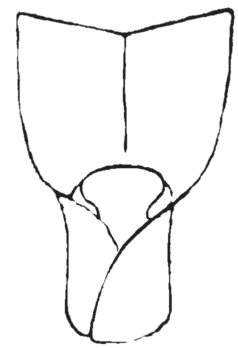
auricles: clasping *(Barley & wheat have also)*

rhizomes: long, whitish, slender

other: perennial, cool season

GRASS FAMILY

Wirestem muhly (29)



stems: rounded; wiry

leaves: numerous, relatively short, narrow, pale green

ligule: membranous; easily visible

auricles: absent

rhizomes: short, scaly, irregularlly shaped; short internodes = many buds

other: perennial, warm season; prolitic seed producer

Identification of Common Wisconsin Weeds

Annual Broadleaves

Jerry Doll, UW Madison Agronomy

Buckwheat Family

Wild buckwheat (51)*

cotyledon:	oblong-oval with granular-waxy surface
ocrea:	at leaf axils; small
stems:	trailing vines
leaves:	heart-shaped with pointed tips
flowers:	greenish-white, small and inconspicuous
seeds:	3-sided

Buckwheat Family

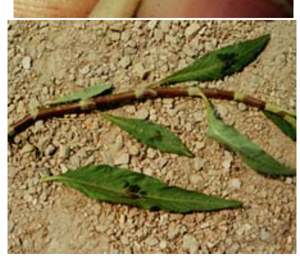
Pennsylvania smartweed (52)

cotyledon:	lanceolate to oblong, rounded tips
ocrea:	at leaf axils; smooth top
stems:	reddish, branched swollen nodes
leaves:	rounded at base; pointed at tip
flowers:	pink, terminal flower clusters
other:	seed black, shiny, flattened, circular with pointed tip

Buckwheat Family

Ladysthumb smartweed (52)

cotyledon:	lanceolate to oblong, rounded tips
ocrea:	at leaf axils; hairy top
stem:	reddish with swollen nodes; branched
leaves:	pointed at both ends, often have “thumb print”
flowers:	pink, terminal flower clusters
other:	seeds black, most triangular

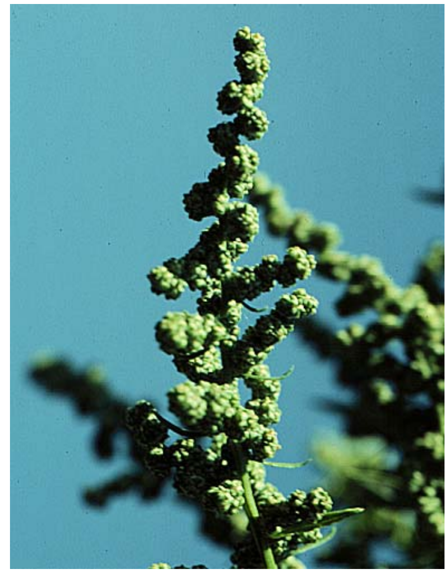


* Numbers indicate the page in *Weeds of the North Central States* that describes the plant.

Annual Broadleaves

Goosefoot Family

Common lambsquarters (57)

cotyledon:	linear, small
leaves:	often have whitish, 'mealy' covering; shape is triangular or "goosefoot" shaped
stems:	have reddish streaks, branched
seed:	shiny, black, disk-shaped, 1/16 inch in diameter
other:	many biotypes, some resistant to herbicides

Pigweed Family

Redroot pigweed (65)


cotyledon:	linear, smooth
root:	often reddish-pink taproot
leaves & stems:	notch in tip of first leaves; finely pubescent; reddish-purple color on underside of leaves
seed head:	somewhat spiny, small, black, shiny seeds
other:	also called rough pigweed

Pigweed Family

Smooth pigweed (64)

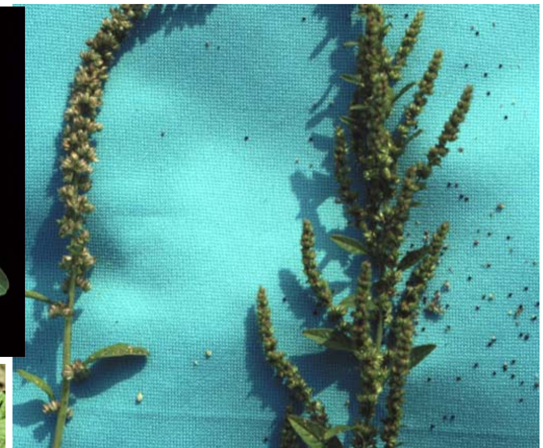


cotyledon shape:	linear, smooth
root:	often reddish pink taproot
leaves & stems:	generally smooth
seed heads:	longer than redroot pigweed ; rarely branched
other:	resistant biotypes

Annual Broadleaves

Pigweed Family

Waterhemp



cotyledon shape:	linear; egg-shaped
leaves:	nick in tip of first leaves; long-petioled; 3 to 6 in. long; somewhat shiny
stems:	smooth, often with colored stripes
infloresence:	small greenish flowers, male and female flowers on separate plants
other:	several species of waterhemp in the region; resistant biotypes

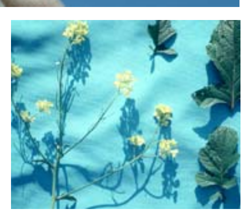
Purslane Family

Purslane (71)

cotyledon:	linear or oblong, smooth
leaves:	fleshy, rounded, opposite
stems:	fleshy, prostrate, reddish, branched
flowers:	5 yellow petals; small; numerous
seeds:	small, flattened, oval, glossy black
other:	plants can establish from stem pieces

Mustard Family

Wild mustard (89)



cotyledon:	heart or kidney-shaped; smooth
leaves and stems:	few bristly hairs
lower leaves:	large, triangular and lobed (not to midrib)
upper leaves:	reduced in size; no petioles
flowers:	4 bright yellow petals
seed pods:	“beak” of seed capsule 1/3 length of whole capsule; open to release round seeds

Annual Broadleaves

Mustard Family

Wild radish (100)

cotyledon:	heart or kidney-shaped, smooth
lower leaves:	rounded lobes often reach to midrib
stems & leaves:	stiff, scattered hairs
flowers:	4 yellowish-white petals; sometimes with purplish veins
seed pods:	form constrictions and break into small segments with seed inside
other:	fruits contaminate oats and barley grain

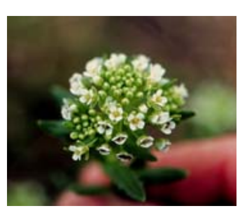
Mustard Family

Shepherd's purse (91)

cotyledon shape:	ovate to rounded
rosette leaves:	starlike branched hairs on upper surface; leaf lobes point to leaf tip
stalk/stems:	elongated stalk; leaves clasp stem
flowers:	small with 4 white petals
seed pod:	small, triangular-shaped

Mustard Family

Field pennycress (104)



cotyledon:	round, bluish-green
leaves:	rosette and stem leaves; ear-like lobes that clasp stems on upper leaves
flowers:	flowers with 4 white petals; in clusters
seed pod:	notch in top of pod and flat wing around edge
other:	garlic-like odor in crushed leaves and stems

Annual Broadleaves

Mallow Family

Velvetleaf (122)

cotyledon:	round or heart-shaped
leaves:	very large, heart-shaped, softly hairy
stem:	pubescent
flowers:	yellow with 5 petals
seed capsules:	13-15 segments; resembles “butterprint”

Nightshade Family

Jimson weed (157)

cotyledon:	lanceolate, smooth
leaves:	ovate (egg-shaped) with pointed tip lobes; wavy margins
stems:	hollow, purplish, and smooth
flower:	white tubular flowers
seed capsules:	spiny, golf ball sized with many seeds
other:	strong, foul odor in leaves and stems; poisonous

Nightshade Family

Eastern black nightshade (162)

cotyledon:	ovate, smooth, small
leaves:	purplish color on underside; often with “shot holes”
stems:	erect or spreading; widely branched
flowers:	5 white reflexed petals
fruits:	green, turning black at maturity; contaminate harvested products

Annual Broadleaves

Nightshade Family

Hairy nightshade

cotyledon: ovate, hairy

leaves: ovate to nearly triangular; finely hairy, especially veins & margins

stems: finely hairy

flowers: 3-9 flowers on short stalk; 5-petaled; white or tinged with purple

fruit: turns yellowish brown when ripe

Gourd Famliy

Bur Cucumber (178)

cotyledon: large; spoon-shaped, thick with dense short hairs

stem: long, ridged vines; sticky-hairy; branched tendrils allow plants to climb over crops

leaves: 3 to 5 shallow lobes (pentagon-shaped), alternate, petioled

flowers: male and female flowers arise at separate axils; 5 greenish-white fused sepals and petals

fruits: in clusters of 3 to 20 egg-shaped, barbed, prickly pods; each pod with one seed

Composite Family

Common ragweed (181)

cotyledon: oval to spatulate, thick

leaves: lacy, finely divided, opposite initially, then alternate; first leaves with 5 lobes

stems: rough, hairy and branched

flowers: male flowers in terminal clusters; female flowers in leaf axils

Annual Broadleaves

Composite Family

Giant ragweed (183)

cotyledon:	oval to spatulate
leaves:	opposite, large and 3-5 lobed; upper leaves often simple; roughly hairy
stems:	woody and 1-2 inches thick; tough, hairy; 6-14 feet tall
flowers:	male flowers in terminal clusters; female flowers in leaf axils

Composite Family

Horseweed (204)

cotyledon:	round to ovate
leaves:	many leaves, no petioles; hairy; entire or toothed
stems:	covered with bristly hairs; branched at top
flowers:	many small flowers on axillary branches
other:	also called marestail; common in no-till sites

Composite Family

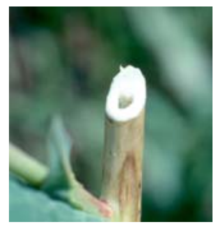
Galinsoga (210)

cotyledon:	oval to squarish, hairy; abruptly tapered at base
leaves:	opposite, toothed
stems:	branched, hairy
flowers:	4-5 white ray flowers surrounding yellow disk flowers

Annual Broadleaves

Zomponte Family

Prickly Lettuce (224)



cotyledon:	ovate to spoon-shaped
first leaves:	rosette of pale green leaves; no spines
later leaves:	lobed with spiny edges and spines on midrib of underside of leaves; leaf bases clasp the stem
stem:	hollow; top very branched when mature
flowers:	pale yellow flower heads that release seeds attached to a pappus
other:	leaves and stems with milky sap

Composite Family

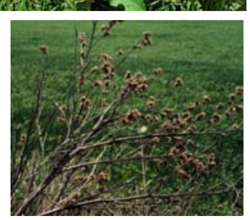
Cocklebur (240)

cotyledon:	lanceolate, thick
leaves:	large, triangular and lobed; 3 prominent veins
stems:	rough texture, dark purple spots
stem & leaves:	sandpaper-like textured surface
flowers:	small, male and female separate but borne together in clusters in axils of upper leaves

Biennial Broadleaves

Composite Family

Burdock (187)



taproot:	large, thick, and fleshy
rosette leaves:	huge with heart-shaped base; white-woolly below
stem leaves:	alternate, prominent veins
stem:	tough; much branched
flowers:	red-violet color; 3/4 - 1 inch across
fruit:	a bur with hooked spines

Biennial Broadleaves

Composite Family

Musk thistle (199)

leaves:	smooth, waxy; grey-green margin with a white, hairless midrib; spiny edges that extend down stem
stems:	spiny from leaf bases except right below flower head
flowers:	1 ½ to 2 inches in diameter; rich pink color; head often tips downward



Composite Family

Plumeless thistle (198)

leaves:	leaves deeply divided; hairy esp. lower surface midrib; decurrent
stems:	spiny from base to flower head due to decurrent leaves
flowers:	¾ to 1 ½ inches in diameter; pinkish



Composite Family

Bull thistle (202)

leaves:	deeply cut, spiny margins with a wrinkled surface; hairy
spines:	prominent; needle-like
stems:	spiny with decurrent leaves (extend down the stem)
flowers:	1 – 2 inches in diameter; are flask-shaped; pink to pink-lavender



Perennial Broadleaves

Horsetail Family

Horsetail (11)

spreads: by spores and rhizomes

fertile stems: stems hollow, not branched; easily separated joints

vegetative stems: "leaves" in whorls at joints; looks like small pine trees

other: most common in wet areas



Buckwheat Family

Curly dock (55)

taproot: fleshy, branched, and yellow

ocrea: long; prominent

basal leaves: 6-12 inches with wavy edges

stems: smooth, erect, reddish

flowers: small greenish becoming reddish brown at maturity, found in dense clusters on branches at tip of stem


Pink Family

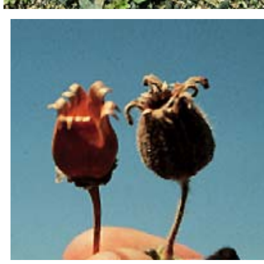
White cockle (74)

leaves: hairy and opposite, with no petiole; softly hairy

stems: softly hairy

flowers: white; male & female parts on separate plants (dioecious)

fruit: seed pods with 10 short teeth


Perennial Broadleaves

Mustard Family

Yellow rocket (86)

rosette leaves:	pinnate with large terminal lobe
stem leaves:	smooth with waxy surface
upper leaves:	clasp stem
flowers:	4 yellow petals, similar to wild mustard but smaller



Mustard Family

Hoary alyssum (87)

stem/leaves:	grey-green in color; rough hairs on whole plant
flowers:	white with 4 deeply-divided petals
fruit:	seed pods small with short “beak”



Spurge Family

Leafy Spurge (118)

roots:	deep and spreading
stems:	smooth
leaves:	alternate, strap-shaped, ¼ inch wide, usually drooping
flowers:	small and borne above greenish-yellow bracts
fruit:	explode when ripe, shooting 3 seeds, from parent plant
other:	all plant parts have milky sap



Perennial Broadleaves

Dogbane Family

Hemp dogbane (134)

roots:	deep and branched
leaves:	opposite, narrow and pointed tips
stems:	smooth, reddish
flowers:	5 greenish white petals that are slightly longer than green sepals
fruits:	long, slender pods; occur in pairs
other:	all plant parts have milky ap

Milkweed Family

Common Milkweed (137)

roots:	deep and branched
leaves:	opposite, thick, oblong, rounded tips, prominent veins
flowers:	pink to white in large many-flowered ball-like clusters at tip of stem and in axils of upper stems
other:	all plant parts have milky sap

Morningglory Family

Field bindweed (139)

roots:	deep and spreading
stems:	trailing or climbing
leaves:	“arrowhead”-shaped leaves with 3 “points”
flowers:	white or pink, funnel-shaped, 1 inch or less in diameter, found in axils of leaves
other:	flower stalks have 2 stipules below flowers

Perennial Broadleaves

Morningglory Family

Hedge bindweed (140)

roots:	deep and spreading
stems:	trailing or climbing (similar to field bindweed)
leaves:	"arrowhead"-shaped leaves with 5 "points"
flower stalks:	no stipules below flowers
flowers:	large, 1 ½ to 2 inches, white or pinkish



Nightshade Family

Horsenettle (160)

root:	spreading, deep with adventitious buds
leaves:	with yellow prickles on the petioles, veins and midribs; hairy; oblong with wavy edges (like oak leaf)
stems:	with sharp, stout spines; simple or branched
flowers:	potato-like with 5 fused white to purple petals; prominent anthers
fruits:	smooth green berries to 0.5" diameter, becoming yellow; become wrinkled and hang on plants most of winter
other:	plants poisonous


Plantin Family

Blackseed Plantin (171)

root:	fibrous, tough
leaves:	in rosette, broad, ovate with 3 to 5 prominent veins; smooth; petioles purplish; egg-shaped, wavy margins
flowering stems:	leafless with many small inconspicuous flowers
other:	broadleaf plantain similar but lacks purple petioles and has smaller leaves


Perennial Broadleaves

Composite Family

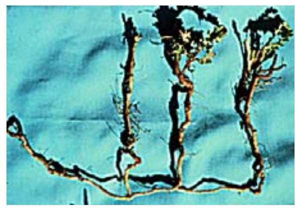
Canada thistle (200)

roots: deep and branched

stems: smooth

leaves: crinkled edges and spiny margins; smooth

flowers: pink to purple, flash-shaped rarely white, ¾ inches wide; male and female flowers on seperate plants



Composite Family

Perennial SowThistle (234)

roots: spreading; shoots arise from buds

leaves: prickly toothed, lobed; milky sap

stems: milky juice; hollow; branch near top

flower heads: branched with yellow ray flowers

seeds: ribbed; with feathery pappus

Composite Family

Dandelion (237)

roots: deep taproot with many buds

leaves: lobes point to base of plant;watery, milky juice

flowers: bright yellow with many seeds

seeds: ribbed with barbs to aid in soil penetration; pappus aids in seed

Key Characteristics of Several Plant Families

A. Amaranthaceae (Pigweed Family)
pigweeds, waterhemp

1. annual herbs
2. alternate or opposite leaves
3. inflorescences dense and spike-like
4. flowers small
5. sepals 3-5
6. petals - none
7. stamens -5
8. fruits - achene or capsule-like

B. Apocynaceae (Dogbane Family)
dogbanes

1. perennial herbs, milky sap in all plant parts
2. stems branched, smooth, fibrous
3. leaves opposite, simple, entire
4. inflorescence terminal or axillary cymes
5. petals and sepals - 5 each
6. fruit - long, slender follicles borne in pairs, often curved
7. seed with pappus

C. Asclepiadaceae (Milkweed Family)
milkweeds

1. perennial herbs or vines, most with milky sap in all plant parts
2. stems unbranched
3. leaves opposite or whorled, simple, entire
4. inflorescence terminal or axillary globe-like clusters (umbels)
5. petals and sepals - 5 each; individual flowers have hour-glass shape
6. fruit - a large, cigar-shaped follicle or pod; often in pairs
7. seed with pappus

D. Caryophylaceae (Pink Family)
chickweed, white cockle

1. herbs
2. annual or perennial
3. opposite entire leaves without petioles
4. nodes usually swollen
5. inflorescences typically cymes
6. flowers - prefect
7. sepals - 5, petals - 5
8. stamens, usually 10
9. fruits - capsules, usually toothed at apex when open

E. Chenopodiaceae (Goosefoot Family)
lambquarters, kochia

1. succulent plants
2. simple, entire or lobed leaves
3. leaves often mealy in appearance
4. flowers in dense axillary clusters
5. flowers greenish
6. sepals - 5, no petals
7. stamens - 5
8. fruits achene-like

F. Convolvulaceae (Morningglory Family)
bindweeds, dodder

1. twining herbaceous vines
2. sap sometimes milky
3. leaves alternate and simple, frequently heart or arrow-shaped
4. sepals - 5
5. petals - 5, almost always completely united
6. stamens - 5
7. fruits - capsules

G. Compositae/Asteraceae (Aster Family)
very large

1. leaves usually alternate, sometimes opposite or whorled
2. petals - 5,4,or none, in florescene a head of several to >100 flowers
3. ligulate(ray) or tubular(disc) flowers, or both
4. head subtended by involucrae bracts
5. pappus of crown-like ridges, scales, awns or bristles
6. fruits achenes

H. Cruciferae (Mustard family)
mustards, wild radish, shepherd's purse

1. leaves mostly alternate
2. inflorescences racemes
3. sepals - 4, petals - 4
4. stamens - 6 (4 long and 2 shorter)
5. fruits, 2-celled siliques

I. Cyperaceae (Sedge Family)
nutsedge

1. annual or perennial herbs
2. triangular solid stems
3. 3-ranked leaves with closed sheaths
4. inflorescences, spikes or panicles
5. style - 1, stigmas - 2 or 3
6. fruits - achenes

—continued on back

J. Euphorbiaceae (Spurge Family)
prostrate spurge, leafy spurge

1. annual or perennial herbs
2. mostly with milky juice (sap)
3. alternate, opposite, whorled leaves
4. inflorescences commonly cymes
5. flowers unisexual and highly variable
6. sepals variable or none
7. petals usually absent
8. stamens - 1 to many
9. fruits usually capsules
10. an extremely variable family

K. Gramineae/ Poaceae (Grass Family)

1. leaves - alternate, parallel veined; with sheath and blade
2. true stems - round or oval, usually hollow between nodes
3. flowers - in spikelets, no petals, 3 or 6 anthers
4. inflorescence - a spike, panicle or raceme

L. Labitae (Mint Family)
healall, henbit, creeping charlie

1. annual or perennial
2. mostly aromatic (odor)
3. square stems and opposite or whorled simple leaves
4. flowers 2-lipped
5. sepals - 5, petals - 5
6. stamens - 2 or 4 (unequal pairs if 4)
7. fruits - 4 nutlets

M. Leguminoseae (Pea Family)
clovers, black medic

1. alternate, usually compound leaves
2. leaves bear stipules
3. inflorescences mostly racemes
4. flowers mostly perfect and irregular
5. sepals usually 5, often united
6. petals - 5, the upper the largest
7. stamens, mostly 10
8. fruits, legumes (true pods)

N. Malvaceae (Mallow Family)
velvetleaf, mallows

1. common in warm climates
2. leaves alternate and usually large, often palmately lobed
3. sepals - 5
4. petals - 5
5. stamens - many
6. fruits - mostly capsules

O. Plantaginaceae (Plantain Family)
plantains

1. annual or perennial herbs
2. basal leaves only
3. inflorescences - bracted spikes
4. flowers small
5. sepals - 4, united
6. petals - 4, papery
7. stamens - 2 or mostly 4
8. fruits - circumscissile capsules

P. Polygonaceae (Buckwheat Family)
smartweeds, knotweeds

1. alternate simple leaves
2. swollen nodes usually
3. ocrea, covering at nodes
4. sepals 2-6 commonly petal-like
5. petals - none
6. stamens - 4-9
7. fruits - achenes, commonly triangular

Q. Solonacae (Nightshade family)
nightshades, groundcherry, jimson weed

1. leaves alternate
2. many species with rank-smelling foliage
3. some species mildly or severely poisonous
4. flowers tomato or potato-like
5. petals and sepals - 5 each
6. fruit - a many-seeded berry; sepals enclose the fruit in groundcherry
7. fruit of jimsonweed golf ball sized capsule covered with blunt spines.

Useful Plant Identification Books

By Jerry Doll and Chris Boerboom, Extension Weed Scientists, University of Wisconsin. Revised October 2001.

Identification of Mature Weeds

Weed identification is a constant challenge for many of us. The best first step to plant ID is to have the appropriate reference materials on hand. Here are those that we find of most help in identifying weed samples.

Books

Weeds of the North Central States. 303 pages with black and white line drawings of mature plants and key features of 230 species. Complete key based on flower color. Available through any County Extension Office. $10.00.

A Field Guide to Wildflowers. 420 pages arranged by flower color. Each chapter with some drawings in color. Available in the Nature section of most bookstores. Paperback. Approximately $18.00.

Weeds of Nebraska and the Great Plains. New and totally revised edition of Nebraska Weeds. Produced in 1994. Excellent color photos and black and white line drawings of 265 species (and descriptions of an additional 125 species) on nearly 600 pages in a hardbound book. Available from the Nebraska Dept. of Agriculture, Bureau of Plant Industry, P.O. Box 94756, Lincoln, NE 68509. $25.00 (includes shipping).

Ontario Weeds. Contains excellent black and white line drawings of 315 species with 28 pages of color plates, each with six pictures in excellent detail. The color photos are grouped so that similar species are on the same page to facilitate easy comparisons of those that look alike. This book is an excellent match for Wisconsin's weed spectrum. Available from the Publications Ontario, 50 Grosvenor St., Toronto, Ontario M7A 1N8, Canada (phone 416-326-5300). The current price is $15.00, add $1.80 for shipping and handling. Order Publication No. 505.

Weeds of the Northeast. It contains nearly 300 species, some of which are not found in either the Weeds of the North Central States or Ontario Weeds. This is one of the few books to include woody species, which are more common with CRP land and increasing no-till acreage. The book contains five "short cut identification tables" that identifies weeds with special characteristics and a standard dichotomous key for all species that is based on vegetative characteristics. Each weed has four or more colored pictures, a narrative (including a useful description of how to distinguish from similar weeds), and line drawings of key characteristics of certain weeds. It is available from Gemplers (phone 1-800-382-8473). The book sells for $32.00 plusshipping and handling fee.

Weeds of the West. A new book from the Western Weed Science Society contains excellent color photographs of nearly 300 species of weeds. Each species is presented with three colors pictures and an easy to read narrative gives the descriptions, habitats and characteristics of each weed. The title is "Weeds of the West" and thus it is no surprise that less than half of the weeds are common in Wisconsin. Nevertheless, for $22.50 (softbound) or $30 (hardbound), this 650 page book is a bargain and it will make a nice addition to your weed ID reference library. Checks should be made payable to the Univ. of Wyoming and orders are then sent to: U.W. Coop Extension Service, Bulletin Room Univ. of Wyoming, PO Box 3313, Laramie, WY 82071-3313.

CD-ROM

Weeds of the United States. 1995. Contains excellent color photos and descriptions of common weeds of the U.S., tutorials, help screens, and other features. Cost is $90.00 or $81.00 each for two or more copies. Order from the Southern Weed Science Society, 1508 West University Avenue, Champaign, IL 61821.

Weed Seedling Identification

Fewer guides are available for weed seedling identification, even though the seedling stage requires accurate identification for selection of proper herbicides or control methods.

Annual Broadleaf Weed Identification (NCR 90) and **Annual Grass and Perennial Weed Identification** (NCR 92), which have photographs and descriptions of the mature stage of the same species. The bulletins are available through any County Extension Office for 65 cents each.

Common Weed Seedlings of the North Central States. This is a nice 22 page bulletin that includes 18 grasses, 1 sedge, and 36 broadleaf weeds. It has a simple key for the grasses and a brief description of each weed. Each weed has a sharp color photograph of the seedling plus two smaller photographs of key features. The bulletin (NCR No. 607) is available through any County Extension Office for $3.00 each.

Weed Seed Identification

An Illustrated Taxonomy of Weed Seeds. This book is the best available for weed seed identification. It contains species in 40 plant families common throughout the Midwest. The illustrations are excellent color photographs of seeds magnified two to six times and are accompanied be a detailed and easy-to-use taxonomic key. Anyone doing weed seed bank work, those participating in crop and weed science contests, instructors of weed science courses, personnel in certified seed laboratories, and anyone with an interest in weed seed identification should have this unique book. It is available from the North Central Weed Science Society, 1508 W. University Ave., Champaign, IL 61821-333. Single copies are $20 (includes shipping).

Weed Seeds of the Great Plains. An excellent reference with 290 species, many common to Wisconsin. The first section, has a list of 22 general characteristics seeds may have. Once you have determined which group a seed belongs to, the subgroup section narrows the choices down to 3 to 10 species. From there, you go to the plant family for a detailed, species by species description of each entry. The final section has superb color pictures of the seeds for each species. Seeds are magnified 2 to 10 times and show great detail. An illustrated glossary at the end of the book gives a definition of all possible seed shapes and shows an outline and cross-sectional view of each one. The book is available from University Press of Kansas, 2501 West 15th St., Lawrence KS 66049-3904 (phone 913-864-4154). Single copies are $25, plus shipping/handling ($3.00 first book by mail/$3.50 by UPS, 50¢ for each additional copy).

Poisonous Plant Reference Books

People are frequently concerned about possible effects of plants on animal health. In recent years, horses seem to be of particular concern in this regard. Here are a couple of useful references on poisonous plants that you may find helpful. Contact the publishers for current prices.

Poisonous Plants of the Central US. H. A. Stephens. 1980. It contains 165 pages and includes black and white photos of several aspects (leaves, seeds, whole plants, etc.,) of many poisonous species. Order from University Press of Kansas, 2501 West 15th St., Lawrence KS 66049-3904 (phone 913-864-4154).

Poisonous Plants of Pennsylvania. R. J. Hill and D. Folland. 1986. It has 175 pages and covers more than 100 species with information on plant identification (including black and white line drawings), plant characteristics, poisonous parts and principles, symptoms of poisoning, and treatment. Order from State Bookstore, 1825 Stanley Dr., Harrisburg, PA 17103. Prepayment is required.

Pasture Plants Toxic to Livestock in Michigan. This 8 page publication is general in nature and gives a description of the plant, the dangerous times of the year, the habitat and distribution, the animals affected and the toxic principles and effects for 23 weeds. These species could also be found in Wisconsin. It also has a table listing crop plants that can possibly be poisonous. Extension bulletin E-1725 available from Michigan State Univ. Coop Exten. Ser., 10-B Agricultural Hall, East Lansing, MI 48824-1039.

Plants Poisonous to Livestock. This 14 page bulletin is similar to the one above and is available from the Univ. of Minn., Coop. Exten. Ser., Publications Office, St. Paul, MN 55108. Ask for bulletin AG-FO-5655-D. Phone 612-625-8173.

The Challenge of Diagnosing Herbicide Injury

Chris Boerboom, University of Wisconsin Extension Weed Scientist

The potential for herbicides to injure crops is real. In most cases, the herbicides that we use are selective, meaning the herbicide only damages weeds and not the crop. The reason for this selectivity is often based on metabolism. The crop is able to metabolize or convert the herbicide into non-toxic chemicals before the herbicide damages the crop plant. For a weed that cannot metabolize the herbicide rapidly, the herbicide is in the plant long enough to damage a chemical process in the plant and kill the weed. There are many factors that can stress a crop plant and cause a normally "safe" herbicide to injure the crop. For example, cold weather can slow the crop's ability to metabolize certain herbicides and hot, humid weather may aid greater herbicide uptake and cause damage from other herbicides. Of course, over-application, drift, carryover, and many other factors can also cause injury.

During your careers, you will be called to trouble shoot why a crop is growing poorly or to confirm a claim of herbicide injury. Herbicides are usually near the top of the suspect list because they are easy to blame and there's a chance the grower may receive compensation. If you are called upon, you have two challenges. First determine what caused the crop injury and then determine how a grower can avoid the problem in the future. Some cases will be simple to solve while others will be more difficult. Before jumping to a hasty conclusion, make sure you have considered all of the evidence. All of the evidence should support the same conclusion. In a tough situation, review the information in the figure below to see if the different facts stack up to support the conclusion that a certain herbicide has caused the injury. After organizing your thoughts in this pattern, it is also easier to help a farmer find a solution to the herbicide problem because you know which variables can be adjusted to prevent the problem in the future.

Field conditions

Be aware of the different conditions that exist in the field. Some of these will cause variation in crop growth by themselves and other can interact with a herbicide and cause or increase herbicide injury. Several clues also become apparent when inspecting the overall field site. The following sections list many factors that can either support or refute a herbicide injury claim.

Weather conditions

Frost, sun scald, sandblasting, and drought are several weather conditions that cause injury by themselves. Know the type of injury they cause and locations in the field where these conditions are more likely to occur. For example, frost can look like injury from certain contact herbicides, but frost can be localized in low areas, especially on peat or muck soils. Check local weather records for this information.

Certain weather creates conditions where herbicides can cause injury. Drought slows herbicide degradation and favors carryover of previously applied herbicides. Heavy rain or irrigation after application of soil active herbicides can leach the herbicide into contact with germinating crop seedlings. Cold, wet soils and cool temperatures can slow the crop's ability to metabolize a herbicide. Hot and humid conditions favor rapid herbicide uptake and activity, which may cause greater injury from postemergence herbicides.

Agronomic conditions

Take note of the cropping system where the poor growth is occurring. Knowing the previous crop helps to determine whether or not herbicide carryover should be considered. No-till fields are more prone to frost even though neighboring tilled fields have not frosted. Check planting depth, which can affect crop safety or can cause herbicide-like symptoms. Also check for soil crusting and compaction. Knowledge of tillage operations and their direction may help explain certain patterns in a field.

Make sure there aren't other problems limiting crop growth like limited fertility, improper soil pH, disease, or insect pests. Soil fertility tests or submitting plant samples for diagnosis of diseases are very inexpensive if you can correct a problem.

Be sure to ask about insecticide use because organophosphate insecticides can interact with several herbicides and cause crop injury. Take note of the variety or hybrid because it may be more sensitive to the herbicide or the variety may just have poor vigor.

Application patterns

When visiting a field, try to walk most of the field looking for patterns. Look from a distance and check different angles. Herbicide injury should be more severe where the spray boom overlapped or where the sprayer may have slowed. These patterns may match herbicide application from the current year or from last year. If the injury follows the spray pattern, double check that the equipment, the spray boom for example, had that width.

Be cautious if the pattern of the injury symptoms don't match the application patterns. See if the injury patterns match with other field operations. Herbicide drift generally tapers off going away from the field edge, whereas herbicide carryover or spray tank contamination are often more uniform across a field.

Soil conditions

Try to match the injury patterns to soil texture, soil organic matter, or the elevation in the field. Soil active herbicides are more active on coarse textured soils and soils with lower organic matter. High soil pH can increase the chance of carryover injury from certain herbicides.

Certain areas of the field may have non-herbicide problems. Ridges and hill tops are more likely to be drought stressed. Frost is more likely in low ground.

Plant injury symptoms

When a herbicide is suspected of causing injury, make sure that the injury symptoms match the key symptoms for that herbicide family. Don't forget to bring a shovel and water to dig, wash and examine the roots for symptoms. If you are trying to determine which herbicide is the culprit, try evaluating the herbicide by the following types of action to narrow down the list of suspects. An excellent reference for evaluating injury symptoms according to herbicide family is "Herbicide Mode of Action and Injury Symptoms", bulletin number NCR377.

Preemergence or postemergence activity

Look at the crop and weeds that grew. Was damage occurring before or shortly after emergence? Soil active herbicides can stop emergence by inhibiting shoot growth or root growth. As a result, crop stands may be thin. Dig up plants that didn't emergence and look for symptoms. Other herbicides are taken up by the roots and the effects are seen shortly after the seedlings come in contact with sunlight. Generally, soil active herbicides will cause injury before or shortly after emergence. Remember a heavy rain may leach a soil active herbicide down to the roots and the injury could then show up after emergence.

Crops or weeds injured from postemergence herbicides will emerge normally and should have a full stand. Injury from postemergence herbicides may occur on leaves that were fully expanded or new growth.

Contact or systemic activity

Contact herbicides do not move within a plant. Their damage is normally limited to existing leaves and new growth is generally unaffected. This type of action makes injury from certain contact herbicides look similar to frost injury.

Systemic herbicides move in the plant. Systemic herbicides taken up by the roots can move either to expanded leaves or to the growing point, depending on the herbicide family. Symptoms from postemergence systemic herbicides often develop first at the growing point. (The growing point of a broadleaf plant is at the top of the plant and the growing point of a grass is at the base of the youngest leaves). Older leaves may show little if any damage.

Herbicides from certain families like the triazines will show systemic action if taken up by the roots and contact action if applied postemergence.

Grass or broadleaf activity

Another quick way to narrow down the list of possible herbicides is to classify the action based on the spectrum of plants affected. Most herbicides have activity primarily on either grasses or broadleaves. Only a couple are truly nonselective like Roundup or Gramoxone.

Confirming facts

While all of the previous information can support a herbicide injury case, the following facts can really tie it all together.

Known herbicide use

Note all of the herbicides and adjuvants, their rates, and when they were applied. Were any unusual tank mixtures applied or was the adjuvant rate and type appropriate for the weather conditions? Check which herbicides were applied last year. If possible, check the amount of herbicide purchased versus the acreage treated to verify that the correct rate was applied. Know the symptoms associated with these herbicides. Remember that almost anything is possible. The spray tank could have been contaminated with another herbicide or a residual herbicide may have been applied by a previous landowner. A herbicide may have been used, but not disclosed by the owner.

To help confirm that a herbicide is causing the problem from over-application or carryover, soil or plant tissue samples can be collected for analysis. Several commercial laboratories can analyze these samples for a fee. If possible, take a representative sample from an unaffected area to compare against the injured area. The test results alone may not conclusively show that the herbicide caused the injury, but the results will show whether or not the herbicide was present and its general level.

Plant growth in check areas

Finally, search the field for possible check areas or spray skips. How does the growth of the crop and weeds in these areas compare to injured areas. These skips can help sort out herbicide injury from carryover, drift, or an application made this year.

Advise on responding to complaints

Here are a few words of advice when called upon to diagnose potential herbicide injury. Try to make your visit to the field in a timely manner before injury symptoms become more difficult to interpret. Take written notes on the information that you receive and the observations you make. If possible, take a few photographs of the symptoms and field. These will help to jog your memory at a later date if needed. Although you were requested to make a judgement by one party, remain neutral and objective until you feel confident in your conclusions. Don't be forced into making an opinion before you are ready. Remember that you can always seek other expert opinion in subject areas where you feel less comfortable.

Herbicide Mode of Action and Injury Symptoms (North Central Regional Publication 377)

UW Extension

Definitions

Mode of action: sequence of events from absorption of the herbicide into the plant until it dies.
Contact herbicide: only injury treated tissue and do not move in plant (non-mobile).
Systemic herbicide: herbicide translocates from site of uptake to other plant parts (mobile).
Epinasty: injury symptom when plant parts are bent or twisted
Chlorosis: injury symptom where leaves or stems turn yellow
Necrosis: injury symptom where leaf or stem tissue dies and turns brown
Callus tissue: mass of plant cells that form on a wounded surface

A. Growth regulator herbicides: cause unregulated growth

- mimic natural growth regulators (hormones)
- selective to________ and are systemic
- symptoms appear first in_______leaves and growing ____________.

1. **Phenoxy acetic acids** (2,4-D, 2,4-DB and MCPA)

    Broadleaves:
    - twisting and bending of stems and leaves (epinasty)
    - callus tissues; "strapping" of leaves

    Grasses:
    - onion leafing or buggy whipping
    - stalk bending and_______________.
    - fused____________________.
    - twisted flag leaves and infertile florets in small grains

2. **Benzoic acids** (Banvel and Clarity)
    - on broadleaves, similar to phenoxys with more cupping; velvetleaf leaves cup upward; soybean leaves puckered;
    - tobacco, soybean, grapes and tomatoes are very sensitive

3. **Pyridines** (Stinger, Crossbow, Confront and Garlon)
    - similar to symptoms above

B. Amino acid synthesis inhibitors: stops production of amino acids needed for proteins and enzymes

1. **ALS inhibitors**

    a. **Imidazolinones** (Pursuit, Raptor, Scepter, Arsenal):

    Grasses:
    - stunted plants with interveinal .
    - root inhibition, pruning of lateral roots, few root hairs

    Broadleaves:
    - stunting to death of terminal growing point
    - back-side of soybean leaves may have__________ leaf veins

b. Sulfonylureas

Accent, Beacon, Exceed, Permit for: ________________.

Classic, Pinnacle, Reliance for : ____________________.

Express, Harmony Extra, Peak for: _________________.

- symptoms similar to those for imidazolinones

c. Sulfonamides (Broadstrike, Python, FirstRate)

- symptoms similar to those for imidazolinones

2. Glyphosate (Roundup, Touchdown)

- nonselective, non-residual, applied postemergence
- foliage turns yellow, sometimes purple, then brown
- symptoms appear slowly, especially in cool weather

C. ACCase inhibitors: stops synthesis of fatty acids needed for cell membranes and new plant growth (Poast Plus, Assure II, Fusilade, Fusion, Select)

- applied postemergence; affect only grasses
- systemic; move rapidly to growing points
- growing point____________and leaves pull easily from shoot
- symptoms appear in 5 to 14 days

D. Seedling growth inhibitors: interfere with plant growth during germination and emergence, generally must be absorbed from the soil

1. Dinitroanilines: inhibits cell division, especially in roots (Treflan, Prowl, Balan, Sonalan)

- stunted plants
- grass shoots may turn ______________ in color
- short, thick roots; clubbed root tips
- broadleaves may have swollen, cracked __________or callus tissue on stems at the soil surface

2. Seedling shoot inhibitors: interferes with lipid synthesis

a. Chloroacetamides (Lasso, Dual, Frontier, Surpass, Harness)

- stunting of grass shoots; leafing out underground
- grasses with "buggy whip" effect
- broadleaves with crinkled leaves and shortened mid-vein, giving a " __________ " effect

b. Thiocarbamates (Eradicane, Eptam, Sutan+)

- grasses with "buggy whip" effect
- broadleaves may have a "bud seal" effect where opposing leaves are stuck together

E. Photosynthesis inhibitors: stops electron transport during photosynthesis which leads to an accumulation of membrane destroying compounds

1. **Mobile:** If soil-applied, herbicides are xylem mobile; if applied postemergence, they act as contact herbicides

   a. **Triazines** (atrazine, Bladex, Sencor, Lexone, Velpar)

   b. **Substituted ureas** (Lorox, linuron)

   - symptoms develop first in the__________and __________leaves
   - chlorosis and necrosis of leaf margins of broadleaves
   - chlorosis and necrosis of leaf tips of grasses

2. **Non-mobile:** contact action only (Basagran, Buctril)

   - most active on broadleaves
   - sprayed leaves become chlorotic or necrotic; spotting or speckling of leaves common
   - oils & additives enhance injury
   - recovery is rapid; new leaves after application are uninjured

F. Cell membrane disrupters: postemergence contact herbicides; produce membrane destroying compounds; fast-acting

1. **Bipyridyliums:** creates free radicals from photosynthesis (Gramoxone Extra, Diquat)

   - nonselective, nonresidual, applied postemergence
   - leaves become limp with water-soaked appearance and then become necrotic
   - particle drift appears as speckling of leaves and stems

2. **Glufosinate:** inhibits glutamine synthetase and causes ammonia to accumulate (Liberty)

   - nonselective, applied postemergence
   - leaves turn chlorotic, then necrotic

3. **PPO inhibitors:** inhibits protoporphyrinogen oxidase (Authority, Blazer, Cobra, Flexstar, Reflex, Resource)

   - primarily broadleaf herbicides, but can affect grasses
   - initial symptom may be bronzing; reddish-colored spots on leaves
   - leaves turn chlorotic, then necrotic
   - soybeans usually recover; new leaves after application are uninjured
   - hot weather and additives increase risk of injury

G. Pigment inhibitors: prevent plants from forming chlorophyll (Balance, Command)

- plants are “whitened/bleached”, especially new growth
- Command vapor or particle drift will bleach sensitive plants; Balance is not volatile
- Command injured plants usually recover
- __________ ,____________and_____________ are very sensitive to Command

Herbicide Mode of Action Key for Injury Symptoms

This key is designed to help you determine which herbicides may be responsible for suspected herbicide injury. This key uses herbicide mode of action because herbicides with the same mode of action cause similar symptoms. After reaching a specific mode of action, you can check if any of the herbicides from that group are the culprit. Also, remember to observe weeds for injury symptoms.

This key is based on three traits of injury symptoms, which can be used to distinguish different herbicide modes of action.
1—If the plant absorbed the herbicide from the soil or if it was absorbed postemergence.
2—If the herbicide translocated to growing points (root tips or meristems) or if the herbicide had contact activity.
3—If the herbicide is selective for grasses or broadleaves or is nonselective.

Injured at Emergence
(soil-applied herbicide or carryover)

Roots Damaged (stunted plants)

Clubbed root tips

Grasses most sensitive
Seedling Root Growth Inhibitor
(Prowl, Treflan)

Pruned roots
Short, slender lateral roots

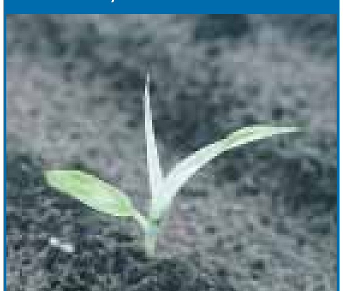
Broadleaf weeds often more sensitive than grass weeds
ALS Inhibitor
(FirstRate, Python, Pursuit, Spirit, etc.)

Root proliferation
Short, thickened roots

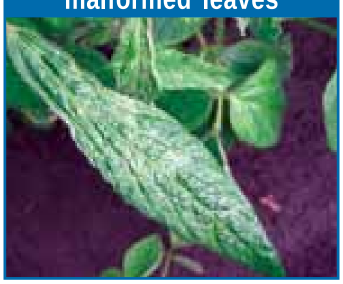
Broadleaves more sensitive than grasses
Growth Regulator
(Banvel, Clarity, Distinct, 2,4-D, etc.)

Roots Normal, Damaged Shoots

White, bleached leaves



May include malformed leaves



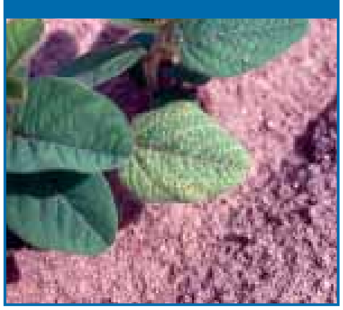
Grasses and/or broadleaves affected
Pigment Inhibitor
(Balance, Callisto, Command)
Mimic: low rate of glyphosate on seedling corn

Chlorotic / necrotic leaf margins

Broadleaves more sensitive than grasses
Photosynthesis Inhibitor
(atrazine, Sencor, etc.)

OR

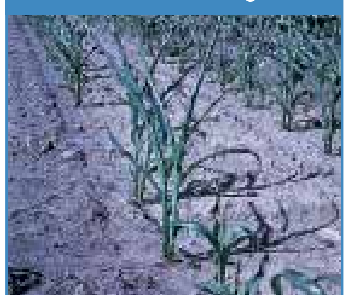
Chlorotic veins



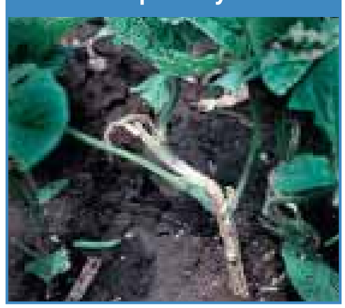
PPO Inhibitor
(Authority, Valor, etc.)

Deformed leaves

Onion leafing

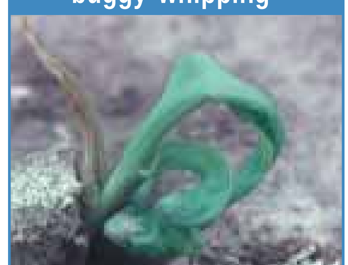


Epinasty

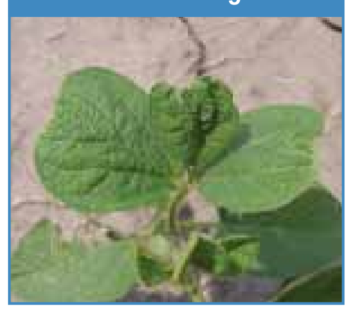


Broadleaves more sensitive than grasses
Growth Regulator
(Banvel, Clarity, Distinct, 2,4-D, etc.)

Leafing out / buggy whipping



Drawstring

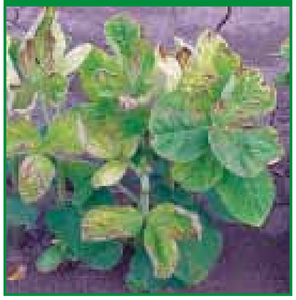


Grasses more sensitive than broadleaves
Seedling Shoot Growth Inhibitor
(Define, Dual, Harness, Outlook, etc.)

Injured after Emergence
(postemergence application, tank contamination, drift)

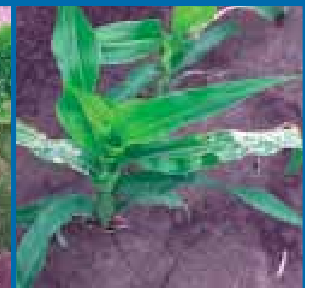
Translocating herbicide
New leaves (meristem) injured, older leaves not injured


Intermediate
White, bleached leaves



Pigment Inhibitor
(Balance, Callisto, Command)

Contact activity
Older leaves injured, new leaves not injured

Broadleaves more sensitive than grasses
Photosynthesis Inhibitor
(atrazine, Bructril, Basagran, etc.)
or
PPO Inhibitor
(Aim, Cobra, Flexstar, etc.)

Nonselective
Cell Membrane Disrupter
(Gramoxone Max, Diquat)
or
Glufosinate
(Liberty)

Leaf cupping, strapping, epinasty

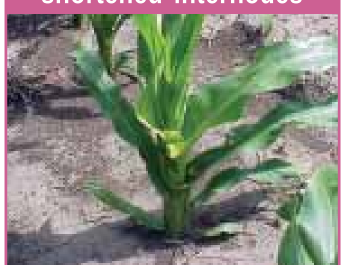

Broadleaves affected more than grasses
Growth Regulator
(Clarity, Distinct, 2,4-D, etc.)

New leaves chlorotic, plants stunted

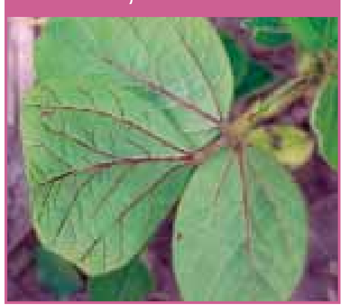
Grass meristems rot

Only grasses affected
ACCase Inhibitor
(Assure, Poast, Select, etc.)

Chlorotic, crinkled leaves, shortened internodes

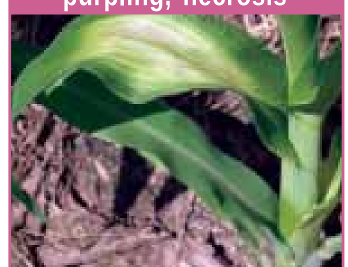
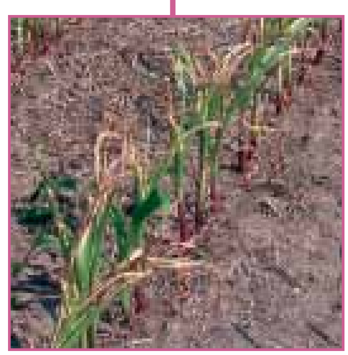


Chlorosis, reddened veins



Broadleaves and/or grasses affected
ALS Inhibitor
(Accent, Option, Steadfast, Classic, Harmony GT, Raptor, etc.)

Variable injury, chlorosis, purpling, necrosis

Nonselective
Glyphosate
(Roundup, Touchdown, etc.)

Integrated Pest Management Program

Author: Chris Boerboom Layout: Mimi Broeske
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