PEST MANAGEMENT

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Competency Area 1: Integrated Pest Management (IPM)

1. Know the definition of IPM and the major IPM strategies.

"Integrated Pest Management (IPM) is a sustainable approach to managing pests by combining biological, cultural, physical and chemical tools in a way that minimizes economic, health, and environmental risks". (National IPM Network).

As defined in the National IPM Roadmap, Integrated Pest Management, or IPM, is a long-standing, science-based, decision-making process that identifies and reduces risks from pests and pest management related strategies. It coordinates the use of pest biology, environmental information, and available technology to prevent unacceptable levels of pest damage by the most economical means, while posing the least possible risk to people, property, resources, and the environment. IPM provides an effective strategy for managing pests in all arenas from developed residential and public areas to wild lands. IPM serves as an umbrella to provide an effective, all encompassing, low-risk approach to protect resources and people from pests.

Another definition: "Integrated pest management (IPM) is socially acceptable, environmentally responsible and economically practical crop protection".

Integrated means that a broad interdisciplinary approach is taken using scientific principles of crop protection to fuse into a single system a variety of management strategies and tactics. Strategies are overall plans to reduce a pest problem. Tactics are the actual methods used to implement the strategy, including such things as chemical, biological, cultural, physical, genetic and regulatory procedures.

Pest traditionally defined as any organism that interferes with production of the crop. We generally think of pests as insects, diseases and weeds, but there are many other types including nematodes, arthropods other than insects, and vertebrates. We now also deal with pests in many non-crop situations, such as human health and comfort, structures, etc.

Management is the decision making process to control pest populations in a planned, systematic way by keeping their numbers or damage at economically acceptable levels.

Key Components of IPM include:

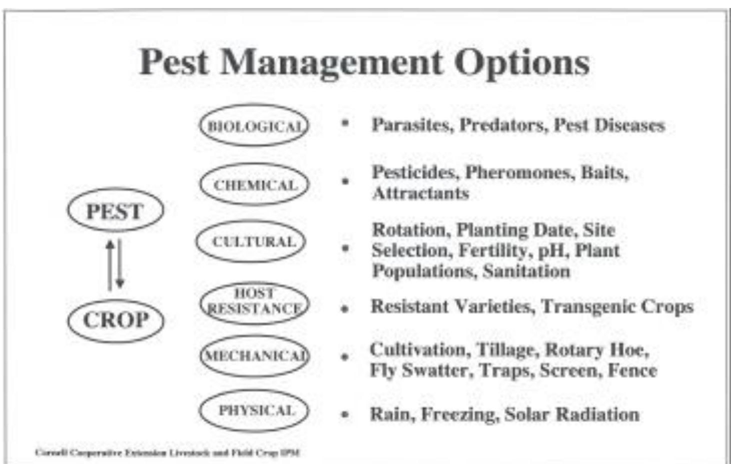
- Integrates management of all pests.
- A way of dealing with pest problems while minimizing risks to human health and the environment.
- Weighs the economic or quality risks of pests and pest control methods used.
- Knowledge-based pest management.
- Reduces pests to tolerable levels – does not emphasize pest eradication or elimination.
- Prevention vs. reactive pest control.
- Holistic approach, ecologically based.
- Uses a diversity of pest control measures.
- Pesticides are used only as a last resort.

What does IPM integrate?

- Multiple pest management tactics (chemical, biological, cultural, mechanical).
- Management of multiple pests (insects, diseases, weeds, vertebrates, etc.).
- Pest Management tactics on an area-wide basis (many pest control situations are better handled on a large-scale or regional basis).

General IPM Strategies:

- *Do-nothing* – Is the pest economically/aesthetically significant? Use sampling and knowledge of economic/aesthetic thresholds to make a decision; if pest population is below the economic/aesthetic threshold, the control is not justified.
- *Reduce Numbers* – Implement on a treat-as-needed basis when the economic injury level is reached, or as a preventative tactic based on history of a pest problem. Examples of tactics pesticides, release of natural enemies, cultural practices such as cultivation, sanitation, etc.
- *Reduce-crop/host/ecosystem susceptibility* – rely on changes made in the host (plant or animal) or ecosystem that make it less susceptible to the pest (i.e., raise the economic injury level). Examples of tactics host plant (or animal) resistanc, tolerance, cultural practices such as fertilization (reduce stress) and altering the synchrony between pest and susceptible host, etc.
- *Combined strategies* – Diversification is often helpful in improving consistency of a pest management program.



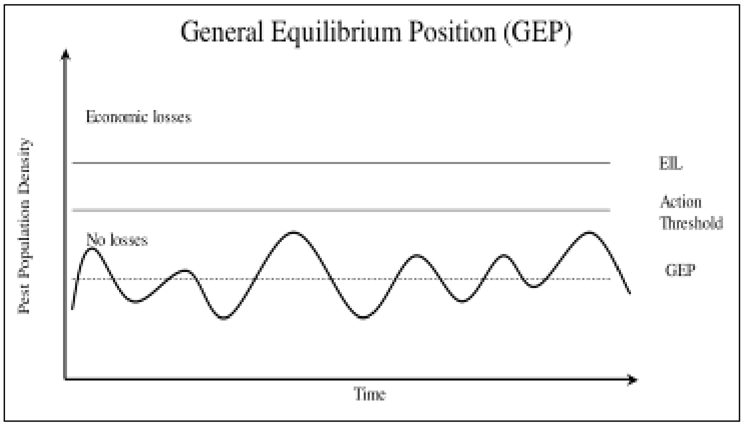
Examples of pest management options are presented in the figure on the left.

Another way of looking at selecting pest management options is to view them as a pyramid where options are arranged as a pyramid. The pyramid illustrates a least toxic approach to pest management. The foundation contains practices such as crop rotation that enhance crop health and help prevent or avoid pest population build up or reduce pest impacts. As one climbs the pyramid towards the top different options are employed *as necessary* as interventions to pest population buildup or impact.

IPM Summary.

Integrated pest management (IPM) helps reduce management risks and optimize the economic efficiency of pest control decisions through (1) early detection of pests, (2) proper identification of pests, (3) accurate assessment of potential for economic impact, and (4) timely employment of appropriate, economically efficient, and environmentally sound management strategies.

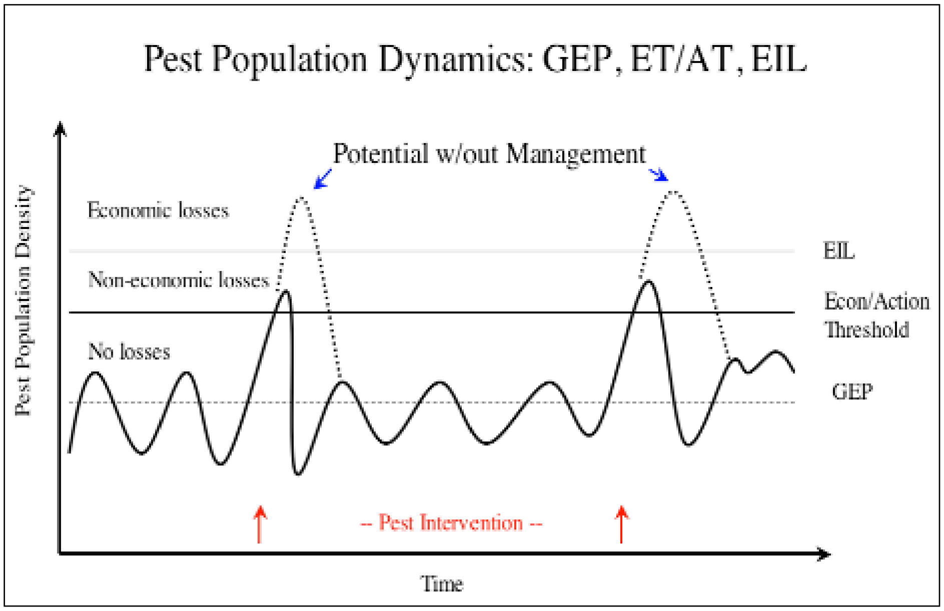
2. Know the relationship between the economic injury level, economic threshold, action threshold and general equilibrium position of a pest population.



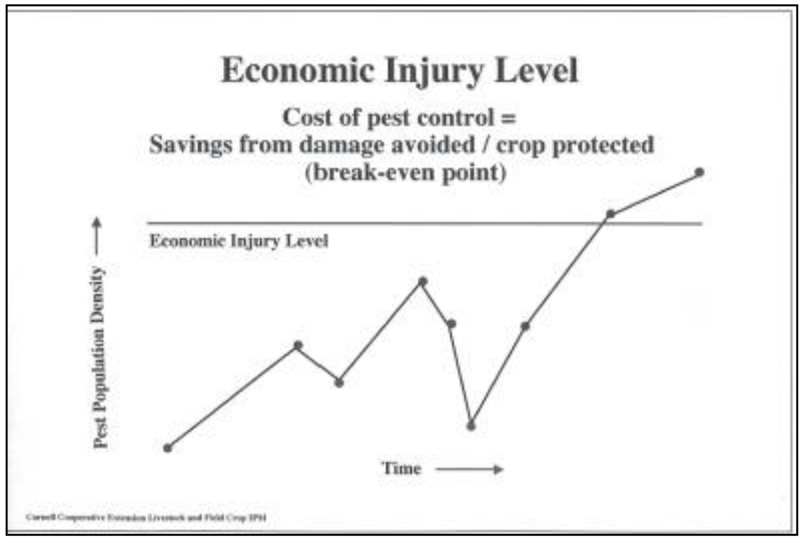
In most crops, and most seasons, a pest species that feed on or otherwise affect the crop will be present at some point in the plant life cycle. However, just because the pest is present does not necessarily mean that the farmer needs to take action against the pest.

"In seeking to reduce a pest's long term average density, the **general equilibrium position** (GEP), is low compared with the economic threshold (problems are not particularly severe), the best strategy would be to dampen pest population peaks. This action would not change the GEP appreciably, yet would prevent economic damage from occurring during outbreaks." By contrast, "severe pest problems call for more drastic population reductions. With these pest problems, the GEP lies very close to or is above the economic threshold. What is required for these populations is a general lowering of the GEP so that highest population peaks never reach the economic threshold."* (Pedigo 1989).

How does the farmer know when the number of pests in his/her crop is too many? Is this number the same every year in all fields? To help farmers decide when there are too many pests, the concept of the "Economic Injury Level (EIL)" is used. The EIL allows the farmer to compare the value of the damage the number of pests in the field might do to the crop with the cost of taking action against the pest. In other words, is the cost of taking action (e.g spray) more or less than the value of crop lost to the pest if no action is taken? The point where the cost of control equals the value of loss is called the EIL.



After Pedigo (1989).



Economic Injury Level (EIL):
The pest population density where the cost of control equals the value of the damage prevented if a control treatment is applied. Or, according to Stern et al. (1959): "The lowest population density of a pest that will cause economic damage; or the amount of pest injury which will justify the cost of control."

Aesthetic-injury Level (AIL):
According to Stern et al. (1959): "Analogous to the EIL, except that aesthetic rather than economic considerations motivate the pest management decisions."

Simplified equation for calculating an EIL (from Pedigo, L.P. 1989. Entomology and Pest Management. MacMillan Pub., NY. 646 pp.):

The major components in a simplified equation

- V = Market Value of per unit of produce (for example, $/acre)
- I = Injury units per production unit (for example, % defoliation/insect/acre, expressed as a proportion)
- P = Density or intensity of pest population (for example insects/acre)
- D = Damage per unit injury (for example, bushels lost/acre/percent defoliation)
- C = Pest Management Costs ($/acre)

Economic Injury Level (EIL) = P

$$P = \frac{C}{V \times I \times D}$$

In instances where some loss from a pest is unavoidable, for example, if injury can be reduced only 80%, then the relationship becomes:

$$P = \frac{C}{V \times I \times D \times K}$$

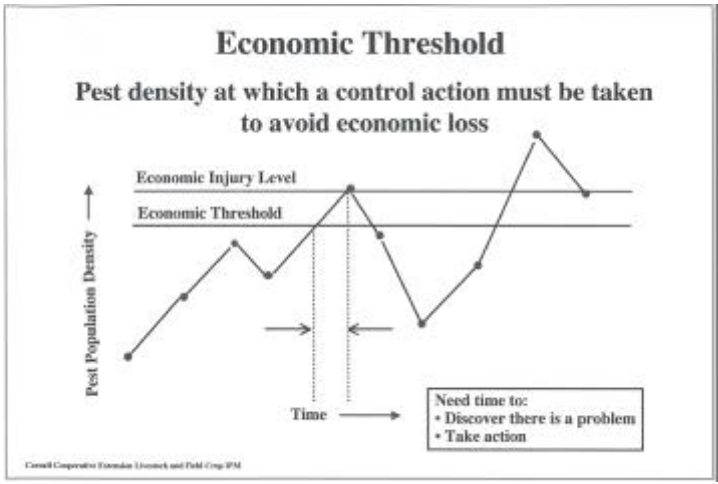
Where K = proportionate reduction in injury (for example, 0.8 for 80%)

There is one more concept that is important. Given that we can calculate the EIL, by the time that the farmer determines that the pest population is getting to unacceptable levels and finds the time, equipment and help he/she needs to take action, the pest population has had a chance to exceed the EIL and eat into the farmer's profit. To account for this management 'lag' another measure, the Economic Threshold sometimes called *Action Threshold*, has been calculated to account for the farmer's reaction time.

Economic Threshold (ET):
The level of pest infestation at which management action is justified.

At or above this level, the likely loss from crop damage is greater than the cost of control. Below this level, the cost of control is greater than the savings from crop protection.

These thresholds are pre-calculated by researchers, so all the farmer has to do is take a proper sample of the pest to answer the question: Are we above or below the Economic Threshold for pest X?



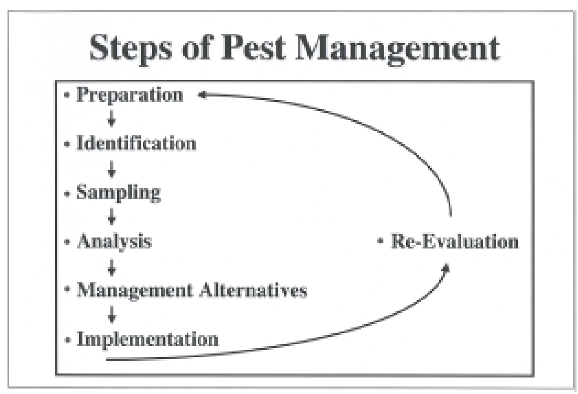
To calculate Economic Threshold you must:

5. Know how to identify the pest
6. Know how to sample the crop environment to assess level of infestation
7. Know stage of crop development and how that relates to severity of damage
8. Know approximate economic threshold levels (available from your state University Extension)
9. Consider how action threshold may vary with stage of crop development, value of crop and cost of control.

For more information see: Understanding the Economic Threshold Concept. In: Field Crop Integrated Pest Management Training and Reference Manual, Penn State University, http://paipm.cas.psu.edu/fldcrop/part3.htm.

3. Know the typical steps in the integrated pest management process. These include:

A. Proper identification of problems
B. Sampling to determine the extent of the problem
C. Analysis to assess problem importance
D. Selection of appropriate management alternative
E. Proper implementation of management action
F. Evaluation of effectiveness of management action



The IPM approach promotes "proactive" rather than "reactive" management. Careful use of these principles in the order presented will maximize the advantages of using the IPM approach. This IPM approach can be applied to a wide variety of pest management situations. With some modifications these IPM steps can be effectively applied to better help manage pests of crops, turf and landscapes, as well as pests of pets and livestock, stored products and pests in/around structures.

The following steps can help you to detect pest problems before they become significant, to prevent losses, and to avoid unnecessary pest management actions:

A. Preparation and planning

Key Issues / Questions…
What should you expect?
Crop agronomy, growth and development?
Pest Management Needs, Options?
Previous field history? Common (annual) pest problems for the crop being produced?
When and how to look to the pest or signs of pest / damage?
Identification – what are key characteristics to correctly identify the pest?
New problems – Are there new, emerging, invasive pest species of potential concern?

Other factors to consider?
Field History – Is there a documented field history with information on previous crop and pest management actions or concerns?
Farm Management – understand the farms resources, strengths, opportunities / constraints, etc.

Resources: Where can you find information?
Cornell Cooperative Extension, Certified Crop Advisors, Company Representatives, other Growers
Cornell Guide for Integrated Field Crop Management (www.fieldcrops.org)
Cornell / NYS Integrated Pest Management: http://www.nysipm.cornell.edu
Trade Journals, etc.

B. Proper identification of problems

Correct identification is the first and most important step in controlling a field problem. This first step is critical to future success, since an incorrect diagnosis leads to mismanagement. What is causing the problem? A pest? An environmental stress? A nutritional deficiency? Or some another factor or combination of factors. Mistaking a disease problem for an insect problem, for example, can lead to an unnecessary use of an insecticide or continued planting of disease-susceptible crop varieties. Confusing a nutritional deficiency for herbicide injury or a disease ailment can likewise lead to incorrect actions. Also, learn to identify parasites and predators that help keep harmful pests in check. Although many insects and other organisms can be observed in fields, relatively few actually harm crops.

Obtain as much information about the problem as possible to determine its cause. Answering several questions will help in this process. What type of damage is observed? Check field history information if available to determine if it is a historical problem? Is the problem found only in particular locations, rows, soil types, drainage patterns, or at certain times during the growing season? What part or growth stage of the plant is affected?

Dig up plants showing symptoms. Check roots and the surrounding soil for evidence of pests. If in doubt about correct identification of the problem collect representative samples and field information to share with other knowledgeable persons or submit to a diagnostic clinic. There are many resources available to provide helpful information on identification of common pest problems of crops. Some suggested resources are listed in the resource section.

This scouting manual discusses the most commonly found pests in alfalfa in New York. A diagnostic guide is included in Appendix A to help you to identify other less commonly observed problems.

Key Issues / Questions…
Mis-identification = mismanagement
Who is your enemy & who is your friend
Be familiar with common, expected problems
Know where on/in the plant / in the field and when (growth stage of crop, time of the season) to anticipate common pests
Know how to distinguish pest damage from other injury (soil compaction, nutrient deficiencies, frost)
Know vulnerable stages of crop and pest, compensation and yield capabilities, potential pest impacts
Know when and how pests can hurt you the most
Be proactive. What crop conditions might favor pest problems?
Wet soils = Phytophthora root rot
Continuous corn – corn root worm, foliar diseases
Poor weed control – armyworm, stalk borer
High crop residue - foliar diseases
Know key beneficial and indicator species, signs of crop health and stress

C. Sampling to determine the extent of the problem

Once the pest is correctly identified, the next question arises: Is there a risk of significant loss? Is the problem occasionally seen? Localized? Or commonly found throughout the field? What is the extent of the damage? Is the problem a growing threat? Scientific sampling / crop monitoring techniques have been developed for assessing the damage potential of many pests. Correct sampling helps eliminate the guesswork in pest control by providing a means to quantify an old problem or discover a new one. Use sampling knowledge and information on pest and crop biology to make better management decisions. For example, the alfalfa weevil, a common alfalfa pest in New York, pupates to the cocoon stage about the time of first harvest, thus alleviating a potential problem naturally. Accurate sampling, or scouting, is systematic and methodical. Examine and quantify all important field information needed to make a sound pest management decision. Information on specific sampling strategies for specific pests on crop of interest can be found in resources such as the Cornell Guide to Integrated Field Crop Management or the New York State IPM website (www.nysipm.cornell.edu).

Pest Forecasting. For some pests forecasting methods have been developed to aide in determining when a pest is likely to be a problem. Weather data and other information help predict when these specific pests will most likely occur. Weather-based pest forecast models for diseases and insects of many crops have been developed in New York. For field crops, information on an alfalfa weevil prediction model based on accumulated heat units is available in the alfalfa insect section of the Cornell field crops guide http://www.fieldcrops.org/. Actual growing degree calculations for predicting estimated alfalfa weevil growth stage across NY during the growing season can be found at: http://newa.nrcc.cornell.edu/newaDisease/alf_weev. Another forecasting model is available to help predict critical times to manage Fusarium Head Blight of Winter Wheat at the Penn State (http://www.wheatscab.psu.edu/riskTool.html). Forecasting models are also available for black cutworm, armyworm, seed corn maggot, a variety of weeds, and other plant diseases.

Access to a computer network to obtain weather, regional insect, and disease forecasts, is useful but not essential. The Northeast Weather Association provides automated local weather information and the results of pest forecasts on a daily basis through computer or fax connection. The NEWA website is:

http://www.nysipm.cornell.edu/newa/. For subscription information, contact NEWA at 315-787-2206. Simple weather-recording equipment such as thermometers, hygrometers, and rain gauges placed in onion fields will assist the prediction of pest outbreaks. Information on the potential for pest outbreaks can sometimes also be obtained from Cooperative Extension offices, newsletters, and crop advisors. Once such resource is the NYS IPM Weekly Field Crops Pest Report found at http://blogs.cornell.edu/ipmwpr/

Key Issues / Questions…
How many pests? General Crop Condition?
What is the extent of the damage in the field? Few plants or areas affected throughout the field? Localized? General problem throughout field? Problem associated with any obvious field factor?
Quantifying an old problem or discovering a new one?
Are pests a "growing" threat? Large cutworms may soon pupate alleviating a problem naturally
Examine and quantify all parameters necessary to make a sound decision
Refer to IPM Guidelines for sampling recommendations and monitoring techniques

D. Analysis to assess problem importance

The third step in the pest management process is analyzing the identification and sampling information and evaluating the need for a pest control action. Decide how bad the problem really is. Is the potential control measure more costly than the damage potential? Weigh economic, environmental, and time concerns. What impact will current pest control decision have on future crop management decisions? Compare the observed frequency of a given pest to its "action threshold." An action threshold is the level at which action must be taken so that the pest will not significantly damage the crop. Action thresholds are based on research and growers' experiences with similar problems.

During the analysis stage, consider the relative vigor of the plants, plant populations, and value of the crop and potential yield. Depending on the crop and pest type. light pest populations may actually increase yields by causing the plant to compensate. Poor stands (less than 75% alfalfa) may not return management dollars since thresholds are based on research with clear stands. For alfalfa stands, crowns should have many lush stems, and little or no signs of root or crown injury, and clear stands probably should have a minimum of five healthy crowns per square foot to justify pesticide application. Clear seeded alfalfa is usually more economical to treat for a given pest problem than mixed stands, and some pesticides cannot legally be applied to mixed stands.

Key Issues / Questions…
Evaluate risk. Is there a significant problem? If so, how bad?
Consult threshold guidelines that are built on research and experience with similar problems
Weigh economic, environmental, & time concerns.
Is damage potential more costly than the control?
What happens if you do nothing? What happens if you apply control(s)?
Which would cost more - damage or control?

Decision aides (See previous Performance Objective (2) and Resource Sections for more information):

- Economic Injury Level (EIL): Pest densities (number of pests per unit area) at which control measures are economically justified.

- Cost of pest control = Savings from damage avoided / crop protected (break-even point).
- Economic Threshold: Pest density at which action must be taken to prevent an impending pest outbreak.
- Action Threshold: The level of pest infestation at which management action is justified.
- At or above this level, the likely loss from crop damage is greater than the cost of control.
- Below this level, the cost of control is greater than the savings from crop protection.

E. Selection of appropriate management alternative

When an action is needed, choose a strategy that fits with the short- and long-term plans, labor force, capital, equipment, and finances of the farm. Evaluate the costs, benefits, and risks of employing various management options. Look for opportunities to integrate different pest control strategies. What are the cultural, mechanical, biological and chemical control options? Which is the most practical, economical, effective choice?

Management tactic	Example
Biological	Parasites, predators, pest
Chemical	Pesticides, pheromones, baits, attractants
Cultural	Rotation, planting date, site selection, fertility, pH, plant populations, sanitation
Host Resistance	Resistant Varieties, Transgenic Crops
Mechanical	Cultivation, Tillage, Rotary Hoe, Fly Swatter, Traps, Screen, Fence
Physical	Rain, Freezing, Solar Radiation

Information on short and longer term pest management strategies can be found in resources such as the Cornell Guide to Integrated Field Crop Management (https://store.cornell.edu/c-875-pmep-guidelines.aspx) or the New York State IPM website (www.nysipm.cornell.edu).

Key Issues / Questions…
What can be done to control this pest problem?
Cultural, mechanical, biological, chemical control options? Economics?
Are there windows of opportunity to disrupt the pests life cycle or potential impact?
Does the total management system allow for some options? Such as: Will early alfalfa harvest to control weevil interfere with crucial corn planting?
Given time and the farm's resources what's the optimum IPM option(s)?
Should option selected be reevaluated? - influence of weed size, insect age, crop growth stage, etc.

F. Proper implementation of management action

Implement the control carefully and at the right time. If pesticides are used, always follow label recommendations. Cultivation or using herbicides on weeds must be done at the right stage of weed and crop development for greatest impact. Pay close attention to the quality control of pest control actions, such as correct calibration of the application equipment and label recommendations. If appropriate, leave small, untreated areas to evaluate control effectiveness. Conduct management action with precision and thoroughness.

Key Issues / Questions…
Timely application of management procedures. Such as using herbicides on weeds at the right stage of development.
Use Quality control. Correct calibration of the sprayer
Integrated approach. Avoid the tendency to use chemicals when effective cultural controls or natural enemies are present
Keep records of actions taken.
Once you have chosen your course of action: Be precise, Be thorough, Be timely, Use quality control.

G. Evaluation management action(s) effectiveness

After a pest control action is taken, review what went right—and equally as important, what went wrong or could be improved. Did the control work? Scout the field again and compare pest activity before and after treatment. Was the problem identified properly? Was the field sampling unbiased? Was threshold guideline used and was it used correctly? Was the choice of control based on sound judgment or outside pressure? What changes to the system would make it better? Enter this information as part of an updated field history. This evaluation step is a very important part of the IPM process since it enables you to learn from experience and find ways to improve management skills and impact.

Key Issues / Questions…
Review what went wrong - what went right
Did you trip up the steps, or climb gracefully? Was the "problem" identified correctly?
Sampling unbiased? Threshold guideline followed?
Choice of control based on sound judgment or salesperson pressure?
Check (no treat) plots to evaluate the action
What changes to the system would make it better?

4. Recognize the importance of using appropriate sampling method to determine presence or absence, and to estimate population density of a species. Know the components of proper sampling including method, location, timing and sample size.

Scientific sampling techniques vary by crop and pest type. Methods to assess the damage potential of important common pests can generally be found in state crop and IPM guides. Sampling techniques and protocols strive to collect information representative of the whole field condition on which to make management decisions. Correct sampling helps eliminate the guesswork in pest control by providing a means to quantify the pest problem. Use sampling knowledge and information on pest and crop biology to make better management decisions. Note: Local conditions may affect crop and pest biology. To most effectively use IPM guidelines, use the sampling methods and threshold guidelines recommended by your state. (For NY field crop IPM: www.fieldcrops.org or www.nysipm.cornell.edu/fieldcrops)

Common methods for sampling:

Visual Inspection for insects, diseases, weeds, vertebrate or other plant damage. Assessments made while walking throughout the field. Data are generally recorded as the number of individuals per plant or plant part or percentage of plants or area affected. Weed assessments include species identification, type (annual, perennial, grass, broadleaf, etc.), and the relative abundance of *important species* in the field. Weed populations can be evaluated using the rating scheme provided in the weed assessment section.

Insects:

- Sweep net or beat cloths – For mobile insects such as potato leafhopper sampling protocols call for using a 15 inch diameter sweep net. Samples are taken a numerous locations within the field. Assessments are made by counting the number of individuals collected in the net per "X" number of sweeps. Beat cloths are another method of collecting information on less mobile insects in row crops, such as spider mites and aphids. The beat cloth is used as a means to collect insects shaken from plants in a sample area such as a square foot. The number of individuals collected per unit area is compared to recommended guidelines.

- Trapping – Several types of trapping devices are used in collection of insect information.
    - Light traps – used to determine relative abundance of insects in a defined region. Information on the number of adults caught in the trap over time is used to help predict potential pest outbreaks.
    - Sticky traps – Used to collect small flying insects such as aphids, leafhoppers, flies, and beetles. Relative abundance and type of insect collected is recorded.
    - Pheromone traps – chemical attractant traps used to determine if a particular species is in the area. Also used to detect initial flights of insects such as European corn borer and the relative abundance of insects like western corn rootworm.

Identification, sampling and management guidelines for specific insects and their damage can be found in state crop and IPM guidelines. Information on specific sampling strategies for specific pests on crop of interest can be found in resources such as the Cornell Guide to Integrated Field Crop Management or the New York State IPM website (www.nysipm.cornell.edu).

Disease Sampling

As different diseases are favored by different environmental conditions, scout for diseases throughout the entire growing season in conjunction with other scouting activities. Diseases may become more obvious during certain times of crop development such as crop emergence, or during times of stress (e.g., drought or flood), and pre- or post-harvest. Look for areas of stunted, yellow, discolored, wilted, contorted or dead plants.

Symptoms of different diseases often appear similar and can at times be confused with other ailments such as nutritional deficiencies and abiotic problems. If a problem cannot be diagnosed in the field, dig up several plants that show typical symptoms. For many diseases it is important to include above and below ground plant parts when submitting samples for diagnosis. For example when submitting alfalfa samples include as much of the crown and taproot as possible. Submit the samples to a diagnostic laboratory (follow recommendations outlined in the *Guidelines for Packaging and Sending Plant Material to the Diagnostic Laboratory* in the appendix).

Estimate the percentage of plants affected by the disease throughout the field. Record information concerning particular problem areas, noting location, size of area affected, drainage pattern, etc.

Weed Sampling

Scout for weeds in the spring and fall. As always, take care to obtain a representative sample of weed conditions throughout the field, although weed infestations may not be uniform across the entire field. Document the weed type rather than taking detailed counts of weed species.

Observe at least five random areas of a forty acre field; divide larger fields into two equal parts for scouting. Base these divisions on previous field history, soil type, topography, or other factors that might affect weed populations.

Scout for weeds in conjunction with other monitoring activities. See the comments above for "Visual Inspection". Record weed type (annual, biennial, perennial, grass, sedge, and broadleaf) and relative importance from all parts of the field. Note any areas with significant weed problems. Map weed locations on the scouting form.

Check special terrain features such as droughty slopes, poorly drained areas, field borders, and fence rows for weeds. These areas can be major sources of weed contamination and differ significantly from the rest of the field.

Specific economic thresholds have not been established for weeds in alfalfa in New York. Instead, use the rating scale provided below and knowledge of the weed type (annual, biennial, perennial, grass, sedge, or broadleaf) to design a weed management program.

Determine the presence of each weed species according to the following rating scheme:

None	No weeds are present.
Few	Weeds are present, but there are very few plants in the field. There are enough plants to produce seed but not enough to cause significant loss.
Common	Plants are dispersed throughout the field. There are a) up to 5 grassy or 3 broadleaf annual weeds per square foot, or b) 0.3 perennial or biennial weeds per square foot (3/sq. yd), or c) scattered spots of severe infestation.
Abundant	There are fairly uniform concentrations of: a) 6 to 20 grassy or 4 to 10 broadleaf annual weeds per square foot, or b) 0.5 to 1.0 perennial or biennial weeds per square ft (6-20/sq yd), or c) scattered spots of severe infestation.
Extreme	There are: a) concentrations of more than 2 grassy or 1 perennial or biennial weeds per square foot (20 grassy or 10 perennial or biennial/sq yd), or b) large areas of severe infestations.

After rating the weeds, rank the most prevalent weed species in each field in order of severity.

5. Outline methods for sampling plant and pest material.

Pest sampling should be based on an understanding of the pest biology. You will need to know pest identification, what to sample (specific areas of the plant, % injury, numbers of insects, an assessment of weed population, etc.), when to sample, how frequently to sample and what constitutes a sample (such as 10 sweep net sweeps per sample site). Sampling for specific pests will often require use of special techniques. Information on pests of concern and when to expect them during the growing season (scouting calendar) for common pests of NY grown alfalfa, field corn, soybeans and wheat/small grains are presented in the Integrated Pest Management (IPM) Literature/Bulletin section. To obtain the latest information on sampling techniques for a specific field crop pest, consult your local Cooperative Extension educator, current *Cornell Field Crop Guide to Integrated Field Crop Management,* or the NYSIPM website.

Correct sampling is the key for obtaining useful field information. It is important to randomly select plants for sampling. Do not examine only the "best" and "worst" plants. A random sample is taken by walking to the general area to be sampled, and looking up to the sky, walk forward five paces. Begin the inspection procedure with the plant nearest the toe of your right foot.

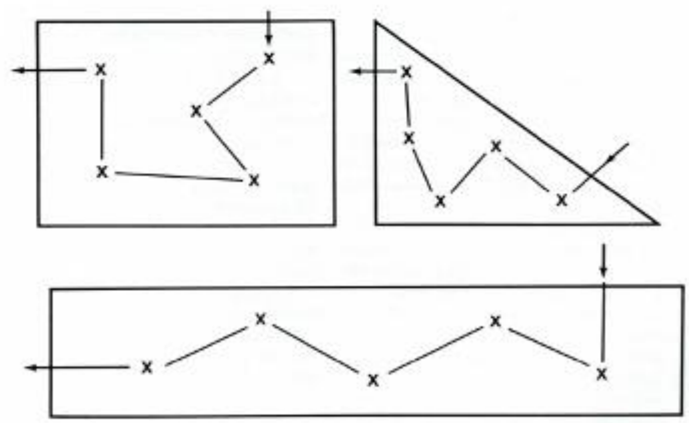
Selecting an appropriate subsample method will depend on the mobility of the pest being scouted. Two subsample methods are recommended:

Consecutive plants are examined when the pest will not be disturbed by sampling procedures on adjacent plants. This method is appropriate for scouting pests such as cutworms, stalk-boring insects, weeds, and diseases.

Random plants are examined when mobile insects are being surveyed. In this case, the next plant examined should be some distance away to remove any possibility of recounting insects that may have moved from plants sampled earlier. Random sampling is the preferred sampling method for insects such as corn rootworm adults.

<u>Sampling Patterns</u>

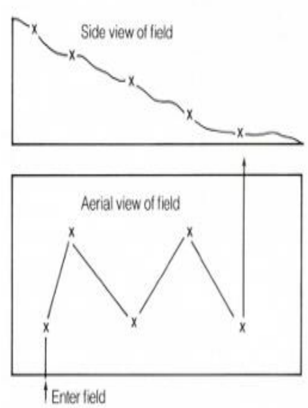
Pests can generally be found in one of three distribution patterns in a field. Scouting efforts for particular pests should be selected accordingly.



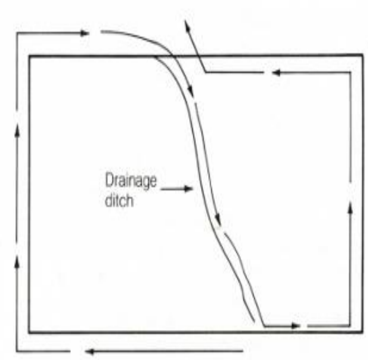
Pattern I example. Sampling pattern for pests expected to have uniform distribution in the field. X = sample area.

<u>Pattern I</u>. Pests are expected to be uniformly spread over the field. In scouting for a pest with this distribution pattern, sample sites are chosen so as to be evenly distributed over the field, obvious influencing factors such as field borders being excluded. Pests fitting this pattern would include European corn borer, corn rootworm adults, potato leafhopper, and most foliar diseases.

<u>Pattern II.</u> Pests are expected to be concentrated in particular areas of the field. Pests fitting this pattern would include black cutworm, white grubs, Phytopthora root rot, or other diseases that may be associated with wet areas within the field or with areas with different soil texture, drainage, pH, fertility, or cropping history. If pests are detected in one area and not in another, efforts should be made to subsample that region to determine the extent and severity of the pest infestation more accurately.



Pattern II example. Sampling pattern for pests expected to be concentrated in areas of the field with unique characteristics.



Pattern III example. Sampling pattern for pests expected to be concentrated along field margins or ditches.

Pattern III. Pests are expected to appear at field edges first. Pests fitting this pattern would include common stalk borer in conventionally tilled corn, spider mites, armyworm, grass sawfly, grasshoppers, and alfalfa snout beetle. Sample for these pests by walking fence rows, ditch banks, and field borders.

NOTE: More than one pest may be present in fields at the same time. For this reason, combinations of the sampling procedures described may be necessary to accurately detect presence of all pests.

- Sampling for specific NY Field Crop Pests can be found in the Cornell Guide to Integrated Field Crop Management (http://fieldcrops.cals.cornell.edu/) and the New York State IPM field crop website (http://nysipm.cornell.edu/agriculture/livestock-and-field-crops).
- Field Crops Pest Management Manual, Purdue University, Agricultural Communication, Media Distribution Center, 231 S University St, West Lafayette, IN 47907-2094, (https://extension.entm.purdue.edu/fieldcropsipm/), 1-888-EXT-INFO (398-4636), Fax: (765) 496-1540.
- Cornell University Integrated Crop Management Guidelines: http://ipmguidelines.org/.
- Penn State Field Crop Integrated Pest Management Training and Reference Manual http://paipm.cas.psu.edu/fldcrop/.
- Pest Sampling and Management Tactics, High Plains Integrated Pest Management Guide for Colorado, Western Nebraska, Wyoming, Montana and Western South Dakota (http://highplainsipm.org/).
- Radcliffe's IPM World Textbook. The University of Minnesota's electronic textbook of Integrated Pest Management (IPM) featuring contributed chapters by internationally recognized experts. (http://ipmworld.umn.edu/).
- Northeast Region Integrated Pest Management Center. Links to IPM information and resources from northeastern US states (CT, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VT, WV) and throughout the United States. http://neipmc.org/index.cfm.

6. Outline methods for submitting plant and pest material for diagnosis and laboratory analysis.

Entomology: http://idl.entomology.cornell.edu/

Cornell University's Insect Diagnostic Lab will help identify the pest and provide pest management suggestions. In addition, check out Cornell University entomology factsheets posted on-line at: http://idl.entomology.cornell.edu/factsheets/

Guidelines for sending specimens:

- Collect and send 10 or more insects, if possible, and all life stages present.
- HOUSEHOLD/STRUCTURAL PESTS: Describe the problem: where found, in what room, approximately how many, extent and type of damage or concern, and history of past infestation.
- PLANT PESTS: Collect progression of symptoms and pests. Include or identify the plant material on which the insects were found -- this is useful and sometimes necessary for pest identification.
- For plant material, collect a fresh sample, wrap it in paper towels, and then in a plastic bag with a few holes. Place in a padded envelope/box. Send early in the week to avoid weekend delays.
- For small plants, you may want to ship the entire plant. Package it so the soil doesn't spill out -- wrap pot with soil in a plastic bag tied about the base of the stem.

- Dead, HARD-BODIED INSECTS such as beetles, wasps, flies, moths, and butterflies should be placed in layers of tissue paper and packaged in a sturdy container for shipping.
- SOFT BODIED INSECTS (Aphids, spiders, mites, grubs, and caterpillars) will break down quickly, so should be prepared and mailed as quickly as possible. It would be best to choose next day delivery if shipping these insects. To kill the insects, small insects such as aphids can be placed directly in a freezer in a bag with a bit of tissue paper to absorb moisture when they defrost. Larger ones such as grubs or caterpillars require preparation to prevent discoloration. They should be dropped into gently boiling water for about 30 seconds; then they may be wrapped in tissue paper and sent. Please indicate original color of specimen.
- Securely wrap the sample and package in a container acceptable to the post office.
- Provide complete collection data: When collected, where collected (town or city or nearest post office), and by whom.
- Send sample early in the week to avoid weekend delays. Mail samples to: Insect Diagnostic Laboratory, 2144 Comstock Hall, Cornell University, Ithaca, NY 14853-2601. Telephone Consultations: (607) 255-4777.

To have the laboratory identify a pest: Download, print, and fill out a Diagnostic Lab Information Sheet available in Adobe Acrobat PDF format. http://idl.entomology.cornell.edu/sample-directions/

- Collect and package a few of the insects following the guidelines listed below.
- Send the sample, information sheet, and check or money order for $25.00 payable to Cornell University to the address listed at the bottom of this web page. We also accept Mastercard, Visa, and Discover credit cards. If you're paying by credit card, we need your card number, expiration date, and the name on the card.
- Optionally, we also provide phone consultations on Tuesdays and Thursdays from 9:00 am to 12:00 noon and 1:00 pm to 4:00 pm eastern time at $10.00 per call. The telephone number is: (607) 255-4777. Please have a credit card ready -- we accept Mastercard, Visa and Discover.
- Insects are identified as quickly as possible. You should have a response within one to three days by e-mail or fax, or one to two weeks by regular mail.

For any questions about sample submission or sample results, and to let us know a sample is being sent, contact: IDLDiagnosticLab@cornell.edu

Collection and Submission of Plant Disease Samples

The Plant Disease Diagnostic Clinic at Cornell University is designed to provide you with diagnostic services. The clinic can provide you with the fast, accurate, professional service that you need and demand. Plant Pathology: http://plantclinic.cornell.edu/. When submitting samples for analysis, please keep a few things in mind:

- Please use the "Submission Form" whenever submitting samples.
- Provide as much information as possible to help ensure an accurate diagnosis of the problem.
- Make sure you include the form with your sample. You may also want to keep one copy of the form for your records. For faster response, include your fax number or email address and indicate how you would prefer to receive the results.
- Please include a check for the appropriate fee made out to Cornell University. We can not process samples until we have received full payment.
- The sample to be submitted should contain all parts of the plant when possible. Wrap the sample loosely in an unsealed plastic bag and package it in a sturdy box. Pack roots separate from branches, shoots, or foliage.

- Mail the sample as quickly as possible. However: there is no mail delivery at Cornell on weekends or holidays. To make sure your sample will get processed as soon as it arrives, collect and ship so that we receive it no later than Friday morning during a regular week. During weeks with major holidays, please call ahead to find out the best time to ship. If the sample cannot be mailed immediately, keep it refrigerated or out of direct sunlight.
- It is important that you try to collect the sample prior to any pesticide applications - once pesticides have been applied it may be difficult to obtain an accurate diagnosis.
- It is helpful if the sample is taken from an area that has early symptoms of the problem. Areas that are completely dead often contain a number of secondary organisms that may hinder the detection of the primary pathogen.

The procedure for collecting samples for nematode analysis varies slightly. Please check the appropriate web page for detailed instructions on collecting and shipping nematode samples. Please feel free to call the clinic with any questions prior to your sample submission. The clinic staff works hard to provide you with fast, accurate results. Providing answers prior to sample submission may enable us to get you the answers you need on a more timely basis. You can contact the clinic by telephone (607-255-7850), fax (607-255-4471), or by email kls13@cornell.edu or slj2@cornell.edu.

For Factsheets http://plantclinic.cornell.edu/factsheets.html. They list useful information about a specific plant disease and provide symptom descriptions and any available control recommendations.

How to Submit a Field Crop Sample:	
Most samples	If you know you are submitting a nematode sample
- The sample to be submitted should contain all parts of the plant when possible. - Wrap the sample in a paper bag and package it in a sturdy box. - Try to mail the sample as quickly as possible. - If the sample can not be mailed immediately, keep it refrigerated or out of direct sunlight. - It is important that you try to collect the sample prior to any pesticide applications. Once pesticides have been applied it may be difficult to obtain an accurate diagnosis. - It is helpful if the sample is taken from an area that has early symptoms of the problem. Areas that are completely dead often contain a number of secondary organisms that may hinder the detection of the primary pathogen.	- The best time of year for nematode analyses is during the active growing season. - A minimum of 6 soil subsamples, approximately 1" in diameter and 4" in depth, should be collected from an area that is approximately one acre in size. - The sub-samples should be collected randomly throughout the area. - The subsamples should be mixed together thoroughly and about a pint of soil transferred to a plastic bag. - Samples should be shipped as soon as possible. If the sample cannot be mailed immediately, keep it refrigerated or out of direct sunlight.

When submitting samples for analysis, please keep a few things in mind: Always fill out the "Submission Form". Providing as much information on the form as possible will help in ensuring an accurate diagnosis of the problem. Make sure you include the form with your sample.

- You may want to keep a copy of the form for your own records.
- Please feel free to call the clinic with any questions prior to your sample submission.
- For faster response, include your fax number or email address and indicate how you would prefer to

receive the results.

- Please include a check for the appropriate fee made out to Cornell University.

For more information see the Cornell University Plant Pathology Diagnostic Clinic Homepage: http://plantclinic.cornell.edu/.

7. List types of pest monitoring methods and the advantages and disadvantages of each.

From: http://ag.udel.edu/extension/iPM/cca/ipmoverview.html.

Monitoring techniques fall into three types: absolute methods, relative methods, and population indices.

Absolute methods: estimates of pest population density are expressed as a level per unit of crop area or as a percentage of the sampling units affected. Examples are direct visual counts per plant or per foot of row or per unit of area.

- *Advantages*: broad range of applicability, less influenced by spatial patterns and changes in pest behavior and sampling efficiency, easier to predict potential crop damage.
- *Disadvantages*: More time consuming

Relative methods: Estimates of pest population activity per unit of effort or time but not expressed with units of the crop area. Examples include visual searches, sweep net sampling, beating or shake cloth estimates, blacklight traps, pheromone traps, visual sticky traps, and bait traps.

- *Advantages*: yield more data given the same effort, less time-consuming, easier to implement.
- *Disadvantages*: efficiency is affected by pest behavior, diurnal activity, weather conditions, the crop habitat being sampled, and variations in the way the methods are deployed; requires more information to relate relative estimates to potential crop damage.

Population Indices: estimates of crop damage or the frequency of pest infestations which indirectly reflect the size of the pest population. Examples are percentage of plants infested or diseased, percentage of defoliation, percentage of damaged fruits, visual ratings of root or foliage injury, etc.

- *Advantages*: less time consuming, easy to implement, more directly related to crop yield losses.
- *Disadvantages*: Cannot be used alone to make control decisions, may not allow enough time to take management actions.

8. Define and distinguish between the following classes of plant response to injury: resistance, tolerance, and susceptibility.

From Agrios, G. "Plant Pathology", Academic press. See also: On-Line Glossary of Technical Terms in Plant Pathology with pronunciation guide, accessible at: http://www.plantpath.cornell.edu/glossary/

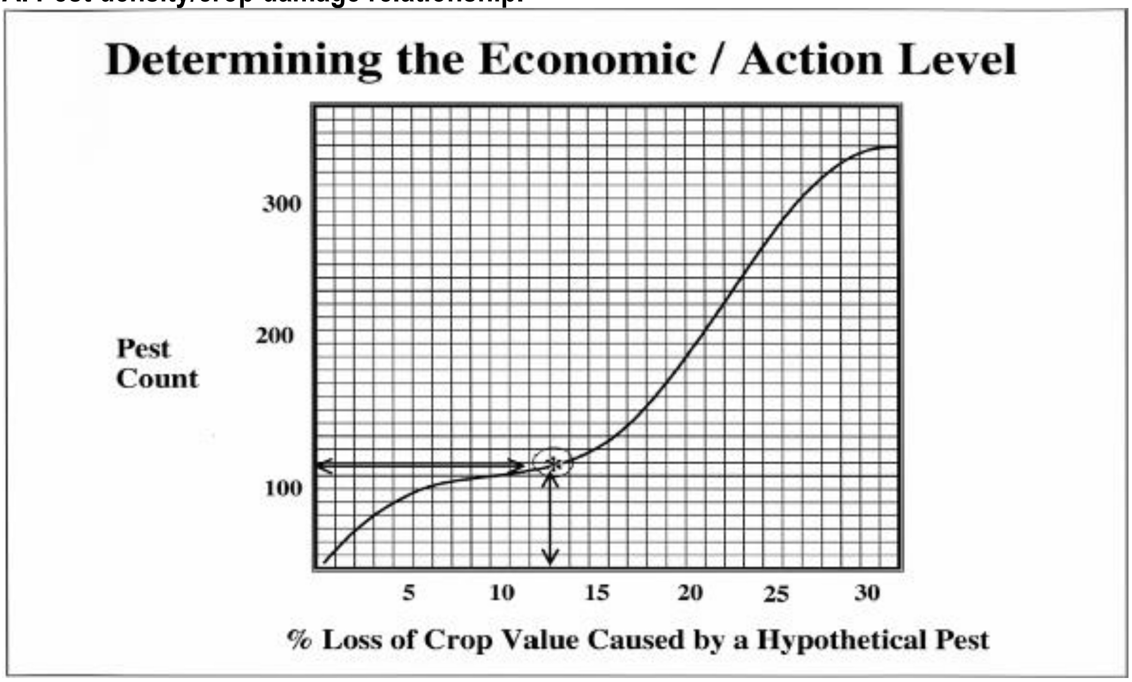
Resistance: The ability of an organism to overcome, completely or in some degree, the effect of a pathogen or other damaging factor. (See also: Plant Resistance to Insects: A Fundamental Component of IPM, G. L. Teetes, Ph.D., Department of Entomology, Texas A&M University, College Station, TX 77843-2475, http://www.plantpath.cornell.edu/glossary/).

Tolerance: The ability of a plant to sustain the effects of a disease without dying or suffering serious injury or crop loss. Also, the amount of toxic residue allowable in or on edible plant parts under the law.

Susceptibility: The inability of a plant to resist the effect of a pathogen or other damaging factor.

9. Recognize how variables including the following are used to calculate the economic injury level (EIL), and how the EIL changes with a change in any of the variables:
A. Pest density/crop damage relationship
B. Crop value
C. Cost of control
D. Effectiveness of control action

A. Pest density/crop damage relationship.



B. Crop value

Information needed:
Value ($) per bushel, ton, salable unit, etc. = **$** _____
Expected yield (bu., ton, salable unit, etc.) per acre = _____
Calculation:
Value ($) per salable unit X Expected Yield / Acre = crop value ($) / acre

C. Cost of control

Estimate Control Cost (Primary + Secondary Costs)

Primary cost (Pesticide cost)
Information needed:
Pesticide use rate (lb., oz, etc.) / acre, i.e. ____(lb., oz, etc.)
Pesticide price / (lb., oz, etc.) $ _____
Calculation:
Pesticide use rate (lb., oz, etc.) / acre, i.e. ____(lb., oz, etc.)
Pesticide price / (lb., oz, etc.) $ _____ =

Pesticide cost / Acre, i.e. $_____ / Acre
Secondary cost
Information needed:
Pesticide Application cost $_____ / Acre

Primary Pesticide Cost + Secondary Cost = Total Pesticide Application Costs / acre
i.e. Total Control Cost $ _____ / Acre

Calculate Maximum Allowable Crop Loss (%)
Total Control cost $ ____ / Acre *divided by* Crop value $____ / Acre =
Maximum allowable crop loss ____%

D. Effectiveness of control action

For more information: Performance Objective (2).

Competency Area 2: Weed Management

<u>Weed Biology</u>

10. Demonstrate familiarity with life cycles and growth habits (dicotyledons and monocotyledons) of weeds and how these characteristics affect weed management.

<u>Life cycles</u>
Annuals - complete life cycle in one year:

- Summer annuals - germinate from seed in spring or early summer then flower and set seed before the end of the growing season, i.e. common ragweed and large crabgrass.
- Winter annuals - germinate from seed in late summer or fall, then flower and set seed the following spring or early summer, i.e. corn chamomile, shepherd's-purse and purple deadnettle.

Biennials - take two years to complete life cycle:

- They make vegetative growth the first year. Then after additional vegetative growth in the second year, they flower and set seed, i.e. common burdock and bull thistle.

Perennials - live for more than two years

- Perennials reproduce from seed only or from seed and vegetative organs.
- Perennial plant forms include:
  - Simple - from seed only, i.e. dandelion and curly dock.
  - Bulbous - from seed, aerial and underground bulblets, i.e. wild garlic.
  - Tuberous - from seed and tubers at tips of rhizomes, i.e. yellow nutsedge.
  - Creeping - from seed and either stolons (prostrate stems or runners that root at the nodes) or rhizomes (underground creeping stems). Rhizomes may be either shallow "rooted" (quackgrass and wirestem muhly) or deep "rooted" (common milkweed and horsenettle).

<u>Growth habits</u> are important because of herbicide selectivity and type/location of growing points (meristems).

- Dicotyledons or broadleaf weeds have two seed leaves and apical/axial meristems so stem elongation is from tip(s).
- Monocotyledons have one seed leaf and basal or intercalary meristems so stem elongation is from the lower portion of internodes.
  - Grasses have hollow round or flattened stems. The parts of grass leaves are:
    - Blade - part of a leaf above the sheath
    - Sheath - lower part of grass leaf that encloses the stem/younger leaves
    - Collar - outer side of a grass leaf at the junction of the blade and sheath
    - Ligule - thin membranous appendage or ring of hairs on the inside of a leaf at the junction of the blade and sheath
    - Auricle - a small projecting lobe or appendage found where the blade meets the sheath
  - Rushes have solid, round stems
  - Sedges have solid, triangular stems

11. Understand the survival mechanisms of weeds, i.e. how they reproduce, spread, and the role seed dormancy plays in survival.

A. Reproductive capacity:
   - Sexual - weeds are prolific seed producers and average about 20,000 seeds/plant (250 from wild oat and 6 million from tumble pigweed).
   - Asexual - vegetative means of reproduction, i.e. bulbs, tubers, stolons, rhizomes, rootstocks.

B. Dissemination of propagules is by wind, water, and animal, especially humans

C. Dormancy or extended viability is the inability of propagules (seeds or vegetative reproductive structures) to germinate when provided with proper conditions:
   - Innate - inherent in mature seed, i.e. mechanically restricted seed coats, impermeable seed coats, germination inhibitors, immature embryos, etc.
   - Induced - become dormant after exposure to environment
   - Enforced - limitations of environment prevent germination

12. Demonstrate the ability to classify each of the following weeds by life cycle and growth habit, i.e. recognize whether they are broadleaf weeds, grasses, or sedges.

Summer Annuals	**Summer/Winter Annual**	**Perennials**
Velvetleaf	Horseweed	Common Milkweed
Redroot/smooth pigweed		Hedge bindweed
Common ragweed		Canada thistle
Common lambsquarters	**Biennials**	Field bindweed
Hairy galinsoga	Common burdock	Smooth bedstraw
Wild mustard	Bull thistle	Horsenettle
Eastern black nightshade		Dandelion
Large crabgrass		Quackgrass
Barnyardgrass		Wirestem muhly
Fall panicum		Johnsongrass
Giant foxtail		Yellow nutsedge
Yellow foxtail		
Green foxtail		

13. Recognize how weed life cycle and growth habit impact choice and timing of control measures.

(See also details under No. 20, especially for postemergence applications.) Weed control measures (methods) limit weed infestations so that crops can be grown profitably or other operations conducted efficiently. Control efforts should exploit biological differences between crops and weeds and should increase competitiveness of crops in comparison with weeds. A successful control program should involve two or more methods of control since relying on only one often results in failure.

Weed Control Methods

14. Mechanical – Understand the advantages and limitations of mechanical control measures, especially those associated with tillage and cultivation.

A. Mechanical control forms:
- o Mowing
- o Burning
- o Smothering
- o Tillage - seedbed preparation and cultivation

B. Advantages
- o Reduce or eliminate herbicides
- o Control weeds that escape herbicide applications, i.e. delay or prevent development of herbicide-resistant weed populations.
- o Sometimes there is a "cultivation effect" that is not related to weed control, i.e. cultivation may improve soil aeration, water infiltration, etc.

C. Limitations
- o Timeliness is critical. Weather/soil moisture conditions may prevent timely cultivation.
- o In-row weed control is difficult with many cultivators.
- o Increased labor costs.

15. Cultural or managerial – Understand the advantages and limitations of cultural practices that influence the competitive relationship between crops and weeds including the role of the following in weed management:

A. Choice of crop and variety/hybrid selection including the advantages and disadvantages of herbicide-resistant crops.
B. Crop rotation
C. Soil management – pH, fertility, soil water
D. Planting date
E. Seeding rate/plant populations/row spacing
F. Nurse crops/cover crops

Cultural or managerial - includes a variety of practices that favor the crop over the weeds - i.e. best management practices

1. Choice of crop and variety or hybrid, including herbicide-resistant crops (HRCs)
   - Advantages or potential benefits of HRCs
     - o New control options for hard-to-control weeds (i.e. perennials)
     - o Increase success and adoption of conservation tillage
     - o Encourage use of thresholds for weed management decisions

   - Aid resistance management
   - Use of environmentally and toxicologically friendly herbicides
   - Minimize herbicide carryover problems
   - Options for limited acreage crops
 - Disadvantages or potential risks of HRCs
   - Unintentional application to, and/or spray drift on susceptible crops
   - HRCs could become weeds in rotational crops
   - Increase selection pressure for herbicide-resistant weeds
   - HRC pollen movement to organically grown crops
   - Invasive potential of HRCs into natural ecosystems
   - HRCs could outcross with closely related weedy relatives
2. Crop rotation
3. Soil management
   - Soil water - drainage/irrigation
   - Soil fertility
   - Soil pH
4. Planting date
5. Seeding rate/plant populations
6. Row spacing

16. Biological – Understand why biological control measures do not work as well with intensively managed crops as in extensively managed production systems/natural areas.

Biological control involves use of natural enemies such as insects, diseases, animals, and other plants. Understand why biological control measures do not work as well with intensively managed crops as with extensively managed production systems or natural areas where you are targeting one weed.

17. Chemical – Be familiar with the ways herbicides are classified, i.e. how they are used and by herbicide family/site of action classification.

Chemical control, as we know it, had its' start in the 1940s with development of 2,4-D. The rapid development of herbicides since then has led producers to think of herbicides as a panacea for their weed problems. They are not a panacea. They are a two-edged sword and should be used as part of an integrated weed management program.

<u>How they are used - selective vs. nonselective</u>

- Foliar applied herbicides
  - Contact - act mainly by touching weeds rather than by being absorbed and moved to the site of action.
  - Trans-located - moved from point of entry to site of action within the plant.
- Soil applied herbicides

<u>Site of action classification.</u>

Mode of action refers to the sequence of events from herbicide absorption into a plant to its' final effect at the site of action. Herbicides with similar chemical structures and herbicidal activity are grouped into families. Two or more herbicide families may have the same site of action within plants and express similar herbicidal activity and injury symptoms. The Weed Science Society of America (WSSA) has approved a numbering system to classify herbicides by their site of action. A Group Number is given to all herbicides with the same site of action.

18. Chemical – Know example herbicides (product names), types of weeds they control, and weed/crop injury symptoms caused by each of the following herbicide site of action groups:

- **A. ACCase inhibitors or lipid synthesis inhibitors (GROUP 1)**
- **B. Amino acid or protein synthesis inhibitors**
    - **i. ALS (acetolactate synthase) inhibitors (GROUP 2)**
    - **ii. EPSP synthase inhibitors (GROUP 9)**
- **C. Microtubule assembly inhibitors or seedling root inhibitors (GROUP 3)**
- **D. Growth regulators or synthetic auxins (GROUP 4)**
- **E. Photosynthesis inhibitors**
    - **i. Mobile photosynthesis inhibitors (GROUPS 5 and 7)**
    - **ii. Non-mobile photosynthesis inhibitors (GROUP 6)**
- **F. Glutamine synthetase inhibitor (GROUP 10)**
- **G. Cell membrane disrupters**
    - **i. PPO inhibitors (GROUP 14)**
    - **ii. Photosystem I electron diversion (GROUP 22)**
- **H. Fatty acid, lipid, protein, inhibitors or seedling shoot inhibitors (GROUP 15)**
- **I. 4-HPPD inhibitors or pigment inhibitors (GROUP 27)**

GROUP 1 – ACCase (Acetyl-CoA Carboxylase) inhibitors (lipid synthesis inhibitors) - prevent formation of fatty acids essential for plant lipids which are vital to integrityof cell wall membranes and growth (46 resistant weed biotypes).
Herbicide Families: 1) Aryloxphenoxy propionate Fusilade DX (fluazifop) – soybeans, dry beans Assure II or Targa (quizalofop) – soybeans, dry beans, snap beans 2) Cyclohexanedione Select Max (clethodim) – soybeans, alfalfa, dry beans, snap beans Poast Plus (sethoxydim) – soybeans, alfalfa, many vegetable crops
Uses – postemergence control of annual and perennial grasses in many broadleafcrops. These herbicides do not affect broadleaf species.
Symptomology – new leaf tissue becomes chlorotic and eventually necrotic. Base of leaves in whorl becomes brown and mushy, and is easily separated from plant. Older leaves may turn purple, orange, or red before becoming necrotic.
Absorption/Translocation – readily absorbed by leaves but slowly translocated downward and accumulate in meristematic regions (gowing points) of shoots and roots.
Soil persistence – short for Select Max and Poast Plus but moderate for Fusilade DX, Assure

GROUP 2 – ALS (acetolactate synthase) inhibitors (protein synthesis inhibitors) – inhibit ALS, a key enzyme in biosynthesis of amino acids needed for protein synthesis. (146 resistant weed biotypes).

Herbicide Families: 1) Imidazolinone Raptor (imazamox) – alfalfa, soybeans, edible legumes, Clearfield crops Pursuit (imazethapyr) - alfalfa, soybeans, edible legumes 2) Sulfonylurea Permit/Sandea (halosulfuron) – field and sweet corn, pumpkins Accent Q (nicosulfuron) – field corn Beacon (primisulfuron) – field corn Resolve Q (rimsulfuron) – field corn 3) Triazolopyrimidine FirstRate (chloransulam) - soybeans Python (flumetsulam) – field corn, soybeans
Uses – postemergence control of a broad spectrum of broadleaf and grass weeds in a multitude of crops. Permit is very effective against yellow nutsedge in corn.
Symptomology – grasses stunted with interveinal chlorosis (yellowing) or purpling; broadleaf plants stunted and chlorotic or purple.
Absorption/Translocation – readily absorbed and translocated to meristematic tissue (growing points).
Soil persistence – varies from short to long and can be affected by soil pH.

GROUP 3 – Microtubule assembly inhibition (seedling root inhibitors)- interfere with cell division and elongation in root tips (12 resistant weed biotypes).
Herbicide Family: 1) Dinitroaniline Balan DF (benefin) - alfalfa Prowl/Pendimax (pendimethalin) – field and sweet corn, soybeans, edible legumes, etc. Treflan (trifluralin) – several vegetable crops
Uses – preplant incorporated, preemergence, or early postemergence control of annual grasses but also control certain annual broadleaf weeds in numerous field and vegetable crops.
Symptomology – highly susceptible weeds do not emerge. Most easily recognized symptom is root inhibition with short, thick lateral roots. This results in deformed shoots. Grass shoots may be red or purple. Broadleaf plants may have swollen/cracked hypocotyls.
Absorption/Translocation – absorbed by emerging shoots (grass coleoptiles, broadleaf hypocotyls) and secondarily by roots. Translocation is not important in control of un-emerged seedlings and upward movement in emerged plants is limited.
Soil persistence – moderately long with half-life of about 45 days.

GROUP 4 – Growth regulators or synthetic auxins – disrupt hormone balance and protein synthesis resulting in abnormal growth. This mechanism of action is not completely understood but the primary action appears to involve cell wall plasticity and nucleic acid metabolism (30 resistant weed biotypes).
Herbicide Familiies: 1) Phenoxy or phenoxyacetic acid 2,4-D – small grains, pasture, field and sweet corn Butyrac 200 (2,4-DB) – forage legumes MCPA – small grains, clover 2) Benzoic acid Banvel, Clarity, Status (dicamba) - field corn, pastures and grass hay 3) Carboxylic acid Garlon (triclopyr) – pastures/hayfields, non-crop areas Stinger (clopyralid) – field and sweet corn, small grains, pastures, etc.

Uses – postemergence control of annual, biennial, and perennial broadleaf weeds in a variety of crops (corn, small grains, pastures, and situations including the use of 2,4-DB and MCPA in legume crops. Limited activity on grasses/grass crops except in seedling stages.
Symptomology – broadleaf plants show epinasty (twisting), callus tissue, and leaf malformations (cupping and curling). Corn can show onion-leafing, fused brace roots, bent and brittle stalks.
Absorption/Translocation – readily absorbed by shoots and roots, and readily translocated both upward and downward in plants. Translocation is generally slower in grasses and other tolerant species.
Soil persistence – short for phenoxyacetic and benzoic acids; moderate for carboxylic acids.

GROUP 5 – Mobile (translocated) photosynthesis inhibitors - bind to site A on the photosystem II complex in chloroplasts and stop carbohydrate production **but binding is different than for Group 7 herbicides** (72 resistant weed biotypes).
Herbicide Families: 1) Triazine or *s*-triazine AAtrex (atrazine) – corn and sorghum Princep (simazine) – corn, tree fruits, etc. Velpar (hexazinone) – dormant established alfalfa, non-crop areas 2) Triazinone or *as*-triazine Sencor (metribuzin) – soybeans, dormant established alfalfa, potatoes, tomatoes 3) Uracil or substituted uracil Hyvar X (bromacil) – non-crop areas
Uses – preemergence and postemergence control of many annual broadleaf and grass weeds and some perennials (Velpar and Hyvar X).
Symptomology – with preemergence applications, seedlings emerge but become chlorotic within a few days. Initially, older leaf margins or tips become chlorotic with interveinal chlorosis in broadleaf plants. Tissue will turn brown and die.
Absorption/Translocation – absorbed through roots or shoots and translocated upward only.
Soil persistence – moderate to long with half-lives of 30-90 days.

GROUP 6 – Non-mobile photosynthesis inhibitors - bind to site B on photosystem II complex in chloroplasts and stop carbohydrate production (4 resistant weed biotypes).
Herbicide Families: 1) Nitrile or benzonitrile Buctril (bromoxynil) – small grains, corn, seedling alfalfa, etc. 2) Benzothiadiazole Basagran (bentazon) – soybeans, beans, peas, corn, etc.
Uses – postemergence control of annual broadleaf weeds but controls topgrowth of certain perennials such as yellow nutsedge and Canada thistle.
Symptomology – postemergence activity only with chlorosis or yellowing followed by desiccation and necrosis. Foliar bronzing may occur on soybeans. Symptoms like those from cell membrane disrupters.
Absorption/Translocation – readily absorbed by leaves with little or no movement to other plant parts.
Soil persistence – little or no soil residual activity.

GROUP 7 – Mobile (translocated) photosynthesis inhibitors – bind to site A on the photosystem II complex in chloroplasts and stop carbohydrate production but **binding is different than for Group 5 herbicides** (25 resistant weed biotypes)**.**

Herbicide Family: 1) Substituted urea Lorox/Linex (linuron) - soybean, corn, vegetable crops. Spike (tebuthiuron) – non-crop situations, industrial sites.
Uses – control annual broadleaf weeds and certain annual grasses, and woody brush (Spike).
Symptomology – with preemergence soil applications, seedlings emerge but become chlorotic within a few days. With foliar applications, interveinal chlorosis and yellowing of leaf margins.
Absorption/Translocation – absorbed through roots or shoots and translocated upward only.
Soil persistence – moderate to long with average half-life of 60 days.

GROUP 9 – EPSP synthase inhibitors (protein synthesis inhibitors) – inhibit EPSP synthase, a key enzyme in biosynthesis of amino acids needed for protein synthesis (31 resistant weed biotypes).
Herbicide Family: 1) Glycine (amino acid derivative) Roundup, Touchdown, etc. (glyphosate) – numerous crops and situations.
Uses – nonselective, postemergence (foliar applied) herbicide for control of most annual and perennial weeds but is most toxic to annual grasses. Can be used for zone/no-tillage burndown and in glyphosate resistant crops.
Symptomology – foliar chlorosis and necrosis with reddish-purple foliage in certain species.
Absorption/Translocation – moderately absorbed by leaves and primarily translocated downward with accumulation in underground tissues, immature leaves, and meristems.
Soil persistence – moderate persistence **but** strongly adsorbed on soil so all crops can be planted immediately after application.

GROUP 10 –Glutamine synthetase inhibitors – accumulation of ammonia destroys cells and directly inhibits photosystem I and photosystem II reactions (2 resistant weed biotypes).
Herbicide Family: 1) None generally accepted (amino acid derivative) Liberty, Rely, Ignite (glufosinate)
Uses – nonselective control of a broad spectrum of annual and perennial grasses and broadleaf weeds. Can be used for burndown in zone/no-tillage and in Liberty Link crops.
Symptomology – chlorosis and wilting within 3-5 days, followed by necrosis in 1-2 weeks.
Absorption/Translocation – absorbed by foliage but movement in plants is limited. Little or no root absorption.
Soil persistence – short soil residual with typical half-life of 7 days.

GROUP 14 – PPO inhibitors (cell membrane disrupters) – inhibition of protoporphyrinogen oxidase results in lipids and proteins being attacked and oxidized. This results in loss of chlorophyll and carotenoids, and in leaky membranes which allows cells and cell organelles to dry and rapidly disintegrate (6 resistant weed biotypes).
Herbicide Families: 1) Diphenylethers Reflex (fomesafen) – soybeans, beans Cobra (lactofen) – soybeans 2) N-phenylphthalimides Resource (flumiclorac) – corn, soybeans Valor SX (flumioxazin) – soybeans 3) Triazolinones Aim (carfentrazone-ethyl) – corn 4) Pyrimidinediones Sharpen (saflufenacil) – corn, soybeans, tree fruit

Uses – pre- and/or postemergence (depending on product) control of a wide spectrum of broadleaf weeds.

Symptomology – following foliar application, leaves of susceptible plants become chlorotic, then desiccated and necrotic within 1-3 days. Sub-lethal rates may produce foliar bronzing. With soil applications, plants emerge, become necrotic and die shortly after exposure to sunlight.

Absorption/Translocation – rapidly absorbed by roots and/or foliage(depending on product and application timing) with limited translocation for some.

Soil persistence – ranges widely from little or none for Cobra, Valor SX, and Aim to long (100+ day half-life) for Reflex.

GROUP 15 – inhibit fatty acid, lipid, protein, etc. synthesis (seedling shoot inhibitors) (4 resistant weed biotypes).

Herbicide Family:

1) Chloroacetamide
   - Harness, Surpass, etc. (acetochlor)
   - Micro-Tech (alachlor)
   - Outlook (dimethenamid-P)
   - Dual II Magnum (*S*-metolachlor)

Uses – preplan or preemergence control of yellow nutsedge, annual grasses, and certain broadleaf weeds such as redroot pigweed.

Symptomolgy – most susceptible weeds fail to emerge. Grass leaves are tightly rolled in the whorl and may not unroll properly resulting in malformed and twisted seedlings. Injured broadleaf species have cupped or crinkled leaves with a drawstring or heart shaped appearance.

Absorption/Translocation – absorbed by emerging shoots, especially grass coleoptiles and broadleaf hypocotyls. There is some root absorption and upward translocation in plants beyond the seedling stage. Translocation is likely unimportant as these herbicides are phytotoxic to emerging seedlings.

Soil persistence – moderate, providing 6 to 12 weeks of weed control.

GROUP 22 – Photosystem I electron diversion (cell membrane disrupters) – lipid oxidation destroys integrity of cell membranes allowing cytoplasm to leak into intercellular spaces which leads to rapid leaf wilting and dessication (31 resistant weed biotypes).

Herbicide Family:

1) Bipyridilium
   - Gramoxone Inteon (paraquat) – burndown for broad spectrum of weeds and crops

Uses – nonselective, foliar applied herbicide commonly used for burndown in zone/no-tillage cropping systems.

Symptomology – rapid wilting and a water soaked appearance followed by desiccation within several hours of application in full sunlight. Necrosis follows within 1-3 days.

Absorption/Translocation – rapidly absorbed into foliage with limited translocation from leaves under normal conditions.

Soil persistence – rapidly and tightly adsorbed to soil and biologically unavailable (inactive).

GROUP 27 – 4 HPPD inhibitors (pigment inhibitors) – inhibit 4-HPPD which affects carotenoid (photosynthetic pigments) biosynthesis (2 resistant weed biotype).

Herbicide Families:

1) Triketones
   - Callisto (mesotrione) - pre- and postemergence in field and sweet corn Laudis
   - (tembotrione) – postemergence in field and sweet corn
2) Pyrazole
   - Impact (topramezone) – postemergence in field and sweet corn

Uses – control of a variety of annual broadleaf weeds and grasses.
Symptomology – bleaching followed by necrosis.
Absorption/Translocation – absorbed by seed and emerging root and shoot following preemergence application (Callisto). Foliar and root absorption following postemergence application. Translocates up and down throughout plants.
Soil persistence – short, for Laudis and Impact, to moderate for Callisto.

19. Chemical – Know time(s) of application for different types of herbicides and how soil (texture, organic matter, pH) and weather (rainfall/soil moisture, temperature, etc.) affect herbicide performance.

A. Preplant - applied before crop is planted
- o Early preplant - surface applied before crop is planted
- o Preplant incorporated
  - Some herbicides require mechanical mixing with soil because they are volatile or subject to photodecomposition.
  - Used to place herbicide near germinating propagules
  - Improve dependability of control

B. Pre-emergence applied to soil surface prior to emergence of crop and weeds; depend on rainfall or irrigation for incorporation and activation.
- o Factors affecting performance:
  - Amount of rainfall or irrigation
  - Herbicide solubility
  - Amount of herbicide adsorbed on soil affects application rates
  - Herbicide chemistry
  - Soil texture
  - Organic matter
  - Soil pH

C. Post-emergence - applied after emergence of crop and weeds.
- o Factors affecting performance:
  - Time of application - should be applied when weeds are young and/or actively growing
    - Summer annuals - young plants in spring or early summer
    - Winter annuals - rosettes in fall or early spring
    - Biennials - fall growth or rosettes in fall or spring
    - Perennials - bud stage in spring or summer or vigorous fall growth
  - Application factors
    - Spray volume
    - Pressure
    - Spray adjuvants - additives that aid or modify the action of the active ingredient(s)
  - Environmental factors
    - Light
    - Temperature
    - Relative humidity
    - Wind
    - Rain

20. Chemical – Be familiar with problems associated with herbicide use

A. Herbicide resistant weeds – Know weeds that have developed herbicide resistant populations in the NE and practices involved in herbicide resistance management.

B. Problems of off-site movement of herbicides.

C. Causes of herbicide crop injury

D. Advantages and disadvantages of herbicide persistence as it relates to weed control, crop rotation, and water quality.

E. Pesticides are potential sources of non-point pollution of surface- and groundwater.

A. Herbicide resistance - has been defined by WSSA as "the inherited ability of a species to survive and reproduce following exposure to a dose of herbicide normally lethal to the wild type. In a plant, resistance may be naturally occurring or induced by such techniques as genetic engineering or selection of variants produced by tissue culture or mutagenesis. http://weedscience.org/Summary/SOASummary.aspx.

- Related definitions include:
  - Cross resistance is resistance to other herbicides within a similar chemical group such as to atrazine and to other triazines.
  - Multiple resistance is the evolution of populations resistant to herbicides not chemically related and having different sites of action.
- Factors that increase the potential for herbicide resistant weed populations include:
  - Weed characteristics that favor resistance
    - Annual weeds
    - High germination rates
    - Produce large numbers of seed
    - Germinate over a long period of time
    - Very susceptible to a herbicide
  - Herbicide characteristics that favor resistance
    - Single site of action in weeds
    - Highly effective on a species
    - High frequency of use
    - High use rate compared to amount needed
    - Long residual activity in soil with noted exceptions
  - Cultural practices that favor resistance
    - Continuous cropping with one crop or type of crop, i.e. RR crops
    - No cultivation or tillage for weed control
    - Using a single herbicide to control specific weeds
    - Continuous or repeated use of a herbicide or group of herbicides that have the same site of action
  - Triazine-resistant weeds in New York State
    - Common lambsquarters (Chenopodium album) – 1977
    - Smooth pigweed (Amaranthus hybridus) – 1980
    - Common groundsel (Senecio vulgaris) – 1989
    - Common ragweed (Ambrosia artemisiifolia) – 1993
  - Herbicide resistance management
    - Rotate crops or type of crop, i.e. RR or LL crops
    - Cultivate to control weeds that escape other measures
    - Use herbicides with little soil activity and/or short residual
    - Rotate herbicide sites-of-action, especially in continuous cropping rotations
    - Use tank mixtures or sequential application with different sites-of-action

B. Problems of off-site movement of herbicides.

- Spray drift - physical movement of spray particles to non-target areas.
- Vapor drift - volatilization of herbicides from plant and soil surfaces with subsequent vapor movement and injury of non-target species.

C. Causes of herbicide crop injury

- Excessive application rates
- Improper application methods
- Synergistic mixtures or sequential applications
- Susceptible hybrids/varieties
- Abnormal soil/climatic conditions

D. Advantages and disadvantages of herbicide persistence as it relates to weed control, crop rotation, and water quality.

- Carryover affecting rotational crops depends on:
  - Herbicide decomposition
    - Microbial
    - Chemical
    - Photodecomposition
    - Plant metabolism
  - Availability for breakdown altered by
    - Volatilization
    - Plant uptake
    - Adsorption on soil colloids
    - Leaching or movement of water through a soil profile may move herbicides
  - Avoid herbicide carryover
    - Read and follow label
    - Use minimum dose
    - Calibration and application
    - Rotate herbicides
    - Use short residual herbicides
    - Integrate with other control measures

E. Pesticides are potential sources of non-point pollution of surface- and groundwater.

- Pesticide data base - provides pesticide surface runoff and leaching potential based on:
  - Half-life - days for concentration to decrease by one-half.
  - Soil sorption index – Koc is measure of tendency to be attached to soil particles.
    - Pesticide chemistry
    - Organic matter content of soil
    - Clay content of soil
  - Water solubility – ppm that will dissolve in water at room temperature
  - Soils data base - soils are ranked according to their potential for pesticide loss through leaching or surface runoff.
  - Soil-pesticide interactions determine leaching and/or surface loss potentials.
    - Potential 1 - has a high probability of being lost to leaching or runoff.
    - Potential 2 - has the possibility of being lost to leaching or runoff.

- Potential 3 - has a low probability of being lost to leaching or runoff.

Competency Area 3: Management of Infectious Plant Diseases

Biology of infectious plant diseases

21. For each of the following field crop diseases:
  A. Classify by type of pathogen
  B. Know the type of symptoms produced and plant parts affected
  C. Know what conditions favor disease development
  D. Know how the pathogen survives between crop seasons
  E. Know other crop species attacked by the pathogen
  F. Know how the pathogen is spread

Answers to performance objectives 22 and 23 are contained in the following tables.

Alfalfa	Wheat
Anthracnose - F	Fusarium head blight (scab) - F
Brown root rot - F	Leaf rust - F
Leaf and stem blight complex including spring black stem and leaf spot, lepto leaf spot, and common leaf spot - F	Leaf and glume blotch complex including Septoria tritici blotch, Stagonospora nodorum blotch, and tan spot - F
Fusarium crown and root rot - F	Loose smut - F
Phytophthora root rot - O	Powdery mildew - F
Pythium damping-off - O	Soilborne wheat mosaic - V
Verticillium wilt - F	Stripe rust - F
	Wheat spindle streak mosaic - V
Corn	Yellow dwarf - V
Anthracnose leaf blight and stalk rot - F	
Common rust - F	Soybean
Common smut - F	Asian soybean rust - F
Eyespot - F	Bacterial blight - B
Gibberella stalk and (red) ear rot - F	Bacterial pustule - B
Goss's wilt - B	Brown stem rot - F
Gray leaf spot - F	Downy mildew - F
Northern leaf blight - F	Northern stem canker - F
Northern (carbonum) leaf spot - F	Pod and stem blight - F
Seed decay/seedling blights – F, O, B	Sclerotinia stem rot - F
Stewart's leaf blight - B	Septoria brown spot - F
	Soybean cyst nematode - N
Oat	Soybean mosaic - V
Crown rust - F	Sudden death syndrome - F
Yellow dwarf (red leaf) - V	

Pathogen type: B = bacterium; F = fungus; N = nematode; O = oomycete; V = virus

Diseases of Alfalfa

Pathogen type: B = bacterium; F = fungus; N = nematode; O = oomycete; V = virus

Disease, type **Symptoms; Host plants**	**Survival & Spread**	**Favored by**	**Control measures and effectiveness (1=high to 3=slight)**
Anthracnose - F Stem lesions, wilt; Alflalfa, clover	Rain-splashed spores (from debris/plants)	Warm, moist weather	Resistant varieties (1) Remove debris from equipment (2)
Brown root rot - F Root/crown rot; Legumes, grasses	In soil	Stresses that weaken plants	Reduce plant injury/stress (3)
Leaf and stem blight complex - Fungi Leaf, stem lesions; Small-seeded legumes	Rain-splashed or airborne spores from infected debris or plants	Moist conditions	Harvest early to reduce leaf loss (3) Foliar fungicides (2)
Fusarium crown and root rot - F Root/crown rot; Many hosts	In soil	Stressed plants; clover root curculio; injured crowns	Reduce plant injury/stress (3)
Phytophthora root rot - O Root rot; Alfalfa	In soil	Wet soils	Resistant varieties (1) Anti-oomycete seed fungicides (2) Soil drainage (2)
Pythium damping-off - O Root/shoot rot Many hosts	In soil	Cool, moist soil	Anti-oomycete seed treatments (1) Good seedbed preparation (2) Soil drainage (2)
Verticillium wilt - F Systemic wilt; Many dicot plants	Soilborne, contaminated harvest equipment	Cool, wet weather	Resistant varieties (1) Rotation with cereals/grasses (3)

Compiled by Gary C. Bergstrom, Cornell University.

Diseases of Corn

Pathogen type: B = bacterium; F = fungus; N = nematode; O = oomycete; V = virus

Disease, type **Symptoms; Host plants**	**Survival & Spread**	**Favored by**	**Control measures and effectiveness (1=high to 3=slight)**
Anthracnose – F Leaf blight, stalk rot; Corn	Rain-splashed spores (local) from corn debris	Mild, wet; reduced-till, continuous corn; European corn borer injury to stems	Resistant hybrids (1-2) Crop rotation (2) Clean plowing (2) Corn borer-resistant (Bt) hybrids (1-2)
Common rust – F Leaf rust; Corn	Airborne spores (long distance)	Humid; thunderstorms	Resistant hybrids (1) Timely planting (2)

Common smut – F Galls on ears, tassel, leaves; Corn	Airborne and rain-splashed spores (in soil)	Injuries; dry conditions	Resistant hybrids (1) Fertilize based on soil test (2)
Eyespot – F Leaf lesions; Corn	Rain-splashed spores (local) from corn debris	Cool, wet; reduced-till, continuous corn	Resistant hybrids (1) Crop rotation (2) Clean plowing (2)
Gibberella (red) ear rot – F Ear rot, mycotoxins; Cereals, grasses	Airborne spores (regional) from corn debris	Moisture at silk emergence	Adapted, less susceptible hybrids (2) Timely planting + harvest (3) Fertilize based on soil test (3) Reduce stresses (3)
Gibberella stalk rot – F Stalk rot Cereals, grasses	Invasion through roots (soil) or wounds	Stressed plants	Adapted, tolerant hybrids (2) Timely planting and harvest (3) Fertilize based on soil test (3) Reduce stresses (3)
Goss's wilt – B Leaf blight, systemic Corn, grasses	Infected corn debris; seed; grass weeds	Rain; reduced tillage; continuous corn	Resistant hybrids (1) Crop rotation (2)
Gray leaf spot – F Leaf lesions; Corn	Airborne spores (regional) from corn debris	Persistent dew, fog; reduced-till, continuous corn	Resistant hybrids (1) Foliar fungicides (2) Crop rotation (2) Clean plowing (2)
Northern leaf blight – F Leaf lesions; Corn	Airborne spores (long distance) from corn debris	Humid, wet	Resistant hybrids (1) Foliar fungicides (2) Timely planting (2)
Northern leaf spot – F Leaf lesions; Corn	Airborne spores (long distance)	Humid, wet	Resistant hybrids (1) Foliar fungicides (2) Timely planting (2)
Seed decay/ seedling blight – F, O, B Seeds, seedlings; Many hosts	In soil; seed	Cool , moist soil; poor quality seed	Protectant seed fungicides (1) Good seedbed preparation (2) Timely planting (2)
Stewart's leaf blight – B Leaf blight, systemic; Corn	Corn flea beetle	Mild winter preceding crop	Resistant hybrids (1)

Compiled by Gary C. Bergstrom, Cornell University

Diseases of Wheat

Pathogen type: B = bacterium; F = fungus; N = nematode; O = oomycete; V = virus

Disease, type **Symptoms; Host plants**	**Survival & Spread**	**Favored by**	**Control measures and effectiveness (1=high; 3=slight)**
Fusarium head blight (scab) – F Head, kernel blight, mycotoxin contamination; Cereals and grasses	Airborne spores (regional) and rain-splashed spores (local) from corn and cereal debris	Moisture at crop flowering through early grain filling	Follow a non-cereal crop (3) Plant less susceptible varieties (2) Stagger planting dates (3) Systemic foliar fungicides at flowering (2)
Leaf rust – F Leaf rust; Wheat only	Airborne spores (long distance)	Warm, humid; thunderstorms in June	Resistant varieties (1) Timely planting (2) Foliar fungicides (2)

Loose smut - F Kernel replacement by spores; Wheat only	In seed (embryo)	Bin-run seed	Certified seed (1) Systemic seed fungicides (1)
Powdery mildew – F Mildew on all plant surfaces; Wheat only	Airborne spores (regional)	Humid; moderate temperatures	Systemic seed fungicides (2) Systemic foliar fungicides (1) Resistant varieties (2)
Septoria tritici blotch – F Leaf blotch Wheat	Wheat debris; windborne	Splashing rain; extended leaf wetness	Foliar fungicides (1)
Stagonospora nodorum blotch – F Leaf/glume blotch; Wheat	In seed; wheat debris; windborne	Splashing rain; extended leaf wetness	Seed fungicides (3) Foliar fungicides (1)
Tan spot – F Leaf spot; Wheat	Wheat debris; in seed; windborne spores	Wheat after wheat; humid, moderate temp.; rainfall	Seed fungicides (2) Partially resistant varieties (2) Foliar fungicides (1)
Soilborne wheat mosaic – V Foliar mosaic, stunting; Wheat, triticale	Transmitted by protozoan; per- sists in soil for many years; limi- ted distribution	Soil moisture at seedling stages; cool spring temperatures	Resistant varieties (1)
Stripe rust – F Leaf rust; Wheat only	Airborne spores (long distance)	Warm/humid;June thunderstorms	Resistant varieties (1) Foliar fungicides (1) Timely planting (2)
Wheat spindle streak mosaic – V Spindle-shaped yellow streaks on leaves in spring; Wheat	Transmitted by protozoan; per- sists in soil for years; wide- spread	Soil moisture at seedling stages; extended cool spring temperatures	Resistant varieties (1)
Yellow dwarf - V Yellowing of leaves, stunting of plants; Many cereals and grasses	Transmitted by aphids (short + long distance)	Early planting; high aphid pop.; nearby infected grasses	Plant after Hessian fly free date (2) Systemic seed insecticides (2)

Compiled by Gary C. Bergstrom, Cornell University.

Diseases of Soybean

Pathogen type: B = bacterium; F = fungus; N = nematode; O = oomycete; V = virus

Disease, type Symptoms; Host plants	Survival & Spread	Favored by	Control measures and effectiveness (1=high; 3=slight)
Asian soybean rust – F Rust on leaves; Soybean, kudzu, perhaps other legumes	Windborne spores (long- distance)	Early arrival of windborne spores; moderate temps.; rain	Application of protectant fungicides prior to infection (1-2) Timely application of fungicides with systemic, curative activity (1)
Bacterial blight – B Lesions on leaves and pods; Soybean	Rain-splashed bacteria from soybean debris; cultivation in wet conditions	Cool, wet weather	High quality seeds (2) Crop rotation (2) Avoid highly susceptible varieties (2)

Disease, type Symptoms; Host plants	Survival & Spread	Favored by	Control measures and effectiveness (1=high; 3=slight)
Bacterial pustule – B Lesions on leaves and pods Soybean	Rain-splashed bacteria from debris or soil; cultivation in wet conditions	Wet conditions	High quality seeds (2) Crop rotation (2) Avoid highly susceptible varieties (2)
Brown stem rot - F Stem rot; premature plant death Soybean	Infected soybean debris; in soil	Cool, moist at seedling stage; hot, dry during pod fill	Resistant varieties (1) Crop rotation (2)
Downy mildew – O Mildew on leaves, pods, seeds; Soybean	Windborne sporangia; sys-temic infection from infected seeds	High humidity; moderate temperatures	Crop rotation (2) Anti-oomycete seed treatments (2)
Northern stem canker – F Stem cankers, stem rot; premature plant death Soybean	Infected soybean debris; in soil	Cool, moist at seedling stage; hot, dry during pod fill	Crop rotation (2)
Pod and stem blight – F Pods and stem lesions; Soybean	Rain-splashed spores from infected soybean debris	Prolonged moist periods during pod maturation	Crop rotation (2) Adapted varieties (2) Timely harvest (2) Late season foliar fungicide application if warranted by disease pressure (1)
Sclerotinia stem rot (white mold) - F Rot of stems; Many dicot plants	Windborne spores from sclerotia on soil surface; in soil	Dense canopy; moisture at flowering; disease in previous crop	Tolerant/resistant varieties (2) Crop rotation (2) Wide row spacing (2) Foliar fungicides (2)
Septoria brown spot - F	Infected soy-bean debris; seedborne	Splashing rain; moist conditions; soybean after soybean	Crop rotation (2) Foliar fungicides, if warranted by disease pressure (1)
Soybean cyst nematode – N Colonizes roots, stunts plants; Soybean only	In soil; movement on equipment, unclean seeds	Infested local soil from which nematode may be introduced into new fields	Avoid introduction (1) Resistant varieties (1) Crop rotation (2)
Soybean mosaic – V Mosaic on leaves, stunts plants; Soybean	Aphid-transmitted (non-persistent) from infected live hosts; seed-transmitted	High aphid populations when plants are young	Plant virus-free seed (1) Timely planting (2) Resistant varieties (strain specific) (2)

Disease, type Symptoms; Host plants	Survival & Spread	Favored by	Control measures and effectiveness (1=high; 3=slight)
Sudden death syndrome – F Root rot; foliar discoloration; premature plant death	Infected soybean debris; in soil	Cool, moist at seedling stage; hot, dry during pod fill	Seed fungicide (1) Crop rotation (2) Control of soybean cyst nematode (2)

Compiled by Gary C. Bergstrom, Cornell University.

Diseases of Oat

Pathogen type: B = bacterium; F = fungus; N = nematode; O = oomycete; V = virus

Disease, type Symptoms; Host plants	Survival & Spread	Favored by	Control measures and effectiveness (1=high to 3=slight)
Yellow dwarf – V Reddened leaves, stunting; Many cereals and grasses	By aphids (short & long distance)	Late planting of spring oat; large aphid populations	Resistant/tolerant varieties (virus strain-specific) (1-2) Plant early in spring (2)
Crown rust – F Leaf rust; Oat, buckthorn	Airborne spores from infected oat or buckthorn	Warm, humid; thunderstorms in June/July	Resistant varieties (race-specific) (1-2) Plant early in spring (2)

Compiled by Gary C. Bergstrom, Cornell University.

Control of infectious plant diseases

22. For the field crop diseases listed under (22) above, know the availability and relative usefulness in disease management under Northeast conditions of:

A. Seed-, foliar-, and soil-applied fungicides
B. Resistant or tolerant crop varieties
C. Use of certified seed
D. Other cultural practices such as rotation, tillage, site selection, soil drainage, planting time, harvest time, fertility, weed and insect control

See tables under 22.

Biology, detection, and prevention of mycotoxins

23. Define 'mycotoxin' and be acquainted with specific mycotoxins: aflatoxins, deoxynivalenol, zearalenone, fumonisins, ochratoxin.

Mycotoxin is a general term for ***a poison produced by a fungus that is harmful to humans and/or animals***. Only certain strains of certain fungi produce mycotoxins, and only under certain environmental conditions. Corn and small grain cereals are especially prone to accumulate mycotoxins in their seed tissues, although the stem (stover) fraction of these crops may also be invaded by toxin-producing molds. Molds may continue to grow and produce toxins in stored commodities under aerobic, high moisture conditions. However our most prevalent problems in the Northeast have been with mycotoxins produced in standing crops prior to harvest. Mycotoxins are only problematic when they occur in commodities and feeds above levels of concern established for individual animal species. Mycotoxin contamination is measured in parts per million (ppm) and parts per billion (ppb).

Aflatoxins:
Produced by the fungus *Aspergillus flavus*, a golden-colored mold; cause liver damage and cancer; tolerances set by U.S. Food and Drug Administration for levels of contamination allowed in milk and other food commodities. Not commonly found in commodities produced in the Northeast but are found in commodities produced in warmer growing regions and shipped to the Northeast.

Deoxynivalenol (vomitoxin):
Produced by certain species of the fungus *Fusarium (Gibberella),* a pink to red-colored mold; cause feed refusal, vomiting, and digestive disorders in swine, dogs, and other species with simple stomachs; chronic symptoms include loss of productivity and lowered immunity; poultry and ruminant animals are less sensitive. USDA recommends less than 1 ppm deoxynivalenol in finished food products and less than 2 ppm in unmilled grain destined for human consumption. Occurs commonly in wheat, barley, and corn grain and silage produced in the Northeast.

Zearalenone:
Produced by certain species of the fungus *Fusarium (Gibberella)*, a pink to red-colored mold; an estrogenic compound that causes reproductive disorders in swine and other species. Occurs commonly in corn grain and silage in the Northeast.

Fumonisins:
Produced by certain species of the fungus *Fusarium*, a whitish-colored mold, and differing from the species that produce deoxynivalenol and zearalenone; cause a fatal brain disease in horses, lung damage in swine, liver damage in several animals, and linked to human esophageal cancer. Occur commonly in corn grain in the Northeast but at fairly low levels. Occur at higher levels in corn produced in warmer regions.

Ochratoxins:
Produced mainly by the fungus *Penicillium*, a blue to green-colored mold, and produced mainly under poor storage conditions rather than in a standing crop; cause damage to the liver and kidneys. Found occasionally in stored commodities in the Northeast.

24. Know the mycotoxins found in Northeast grain and silage, the fungus genera they are produced by, and how they are detected.

Main Mycotoxins occurring in corn hrain and silage produced in the Northeastern United States.

Mycotoxin:	Predominant toxigenic mold:	Lowest level of concern:	Common effects on animals:
Deoxynivalenol (vomitoxin)	*Fusarium graminearum* (*Gibberella zeae*) Causal fungus of Gibberella ear rot and stalk rot of corn; and Fusarium head blight of wheat and barley	1-3 ppm <1 ppm	Feed refusal and gastrointestinal upset and vomiting in animals with simple stomachs; severity increases with level. Swine and dogs are most sensitive; adult cattle and poultry tolerate >10 ppm. USDA guideline for human food product

Zearalenone	*Fusarium graminearum* (*Gibberella zeae*) Causal fungus of Gibberella ear rot and stalk rot of corn; and Fusarium head blight of wheat and barley	1-5 ppm	Hyperestrogenism and infertility. Swine (gilts) are most sensitive; adult cattle tolerate 50 ppm.
Fumonisins	*Fusarium verticilloides; F. proliferatum.* Causal fungi of Fusarium ear rot and stalk rot of corn	5-10 ppm >100 ppm	Brain deterioration, death (horses); liver damage (horses, swine, cattle, poultry). Lung damage in swine

25. Know strategies for minimizing contamination of commodities by mycotoxins.

Greatest mycotoxin risk factors in corn production:

- Moist weather at silk emergence (Gibberella ear rot; deoxynivalenol and zearalenone)
- Drought, high temperatures during grain maturation (Fusarium and Gibberella stalk rots; Fusarium ear rot; fumonisins)
- Insect or other mechanical damage to ears or stalks
- Delayed maturation/delayed harvest
- Contaminated storage structures
- Failure to adequately dry grain or poor ventilation of dried grain storage
- Failure to exclude air from high moisture, anaerobic storage

Field practices that reduce the risk of mycotoxin contamination in corn:

- Timely planting of locally adapted hybrids of appropriate maturity with partial resistance to Gibberella ear rot
- Avoiding continuous planting of corn under conservation tillage, especially where Gibberella/Fusarium stalk rot is prevalent
- Fertilizing based on soil test and avoiding excessive nitrogen
- Avoiding stress from insects, weeds, and excessively high plant populations
- Planning ahead for harvest and subsequent grain handling:
  - Clean grain bins before putting in the new crop
  - Harvest fields with delayed maturity or high lodging potential as silage or grain for anaerobic storage; or be prepared to rapidly dry grain down to 13.5% moisture content
  - Aerate grain bins to prevent moisture migration caused by colder temperatures
  - Harvest silage at recommended plant maturity, and pack well to eliminate air pockets

Testing for mycotoxins

On-site test or laboratory test?
On-site test kits are available through commercial firms. Most are antibody-based and indicate contamination by a color change; other tests utilize thin layer chromatography (TLC) or minicolumns. On-site tests are quick and relatively inexpensive (depends on the number of samples run). They generally give accurate and reproducible results when used on dry grain samples; they are not as reliable for high moisture grain or silage. Specific mycotoxins can be quantified relative to standards that are

supplied with the kits. On-site tests are often used as diagnostic tests. Commercial and government/university labs offer mycotoxin testing. Lab tests are expensive, comprehensive, and quantitative for many toxins, and are useful for wet and dry samples. Methods include high-pressure liquid chromatography (HPLC) and gas chromatography-mass spectrometry (GC-MS).

Sample collection and handling.
Samples must be representative of grain in a truck or bin or silo. Obtain many small samples at periodic intervals from a moving stream of grain or by probing all levels and areas of a stationary grain mass to make a composite 10 lb sample that should be further mixed and subsampled to produce a 2 lb sample for shipping to a lab. Ship dry samples in breathable cloth or stout paper bags. Wet samples should be in sealed containers and be frozen or refrigerated during transit.
More information on on-site tests and/or laboratory analyses is available from:

- Cumberland Valley Analytical Services, Hagerstown, MD. (http://www.foragelab.com/)
- DairyOne Forage Lab, Ithaca, NY. (http://dairyone.com/analytical-services/feed-and-forage/services-and-pricing/)
- Neogen Corporation. (www.neogen.com)
- Romer Labs, Inc.(https://www.romerlabs.com/)
- Trilogy Analytical Laboratory. (www.trilogylab.com)

Competency Area 4: Management of Arthropods

<u>Biology of Arthropods</u>

26. For each of the following:

A. Be able to sight identify.
B. Classify as an important economic pest or a sub-economic/occasional pest.
C. Classify by feeding habit, host range, injury mechanism, symptoms and damaging stage(s).
D. Understand how biology influences management
E. Know how environmental conditions influence population dynamics.
F. Know how the environment influences potential for crop damage.

<u>Corn</u>	***<u>Small Grains</u>***
Western/Northern corn rootworm	**Cereal leafbeetle**
European Corn Borer	**Wireworm**
True armyworm	
Fall armyworm	***<u>Alfalfa</u>***
Black cutworm	**Alfalfa snout beetle**
White grub	**Alfalfa weevil**
Wireworm	**Clover root curculio**
Corn leaf aphid	**Pea aphid**
Slug	**Potato leafhopper**
Seedcorn maggot	

Soybeans	
Seedcorn aphid	
Soybean mites	
Spider maggot	

Arthropods

Class of Arthropods	Common Name	Distinguishing Characteristics
Insecta	Insects	Three body regions (head, thorax, and abdomen), 6 legs and usually 2 pair wings on thorax, 1 pair of antennae.
Crustacea	Crayfish, Sowbugs, Fairy Shrimp	Have 10 to 14 legs, 2 body regions (cephalothorax and abdomen) and 2 pair of antennae.
Arachnida	Spiders, Ticks, Mites, Scorpions	Have 8 legs, no antennae, 2 body regions (cephalothorax and abdomen)
Diplopoda	Millipedes	Have long bodies composed of about 50 segments, each of which has 2 pair of legs.
Chilopoda	Centipedes	Have long bodies composed of 14 to 20 segments, each of which has 1 pair of legs.

Insects, mites and spiders are members of the group (Phylum) of organisms known as Arthropods (Jointed Legs). The other members of the Plylum (group) are listed in the table above.
The Class of Insecta is separated from the Class of Arachnida (mites, spiders) by the number of body parts, number of legs and the presence/lack of antenna. Examples are shown below of the different orders of Arachnida. Agricultural important groups of Arachnida are the mites (plant feeding and beneficial) and spiders (beneficial).

 **Scorpionida – scorpions**	**Pseudoscorpionida – false scorpions**
 **Opiliones - daddy-long-legs or harvestmen**	 **Araneida – spiders**
 **Acari - mites & ticks**	

In contrast, members of **Class Insecta** all have one pair of antennae, three body parts (head, thorax, abdomen), three pair of legs, adults usually have wings and breathing takes place using trachea.

Insect development is divided into two life cycle groups. In the Incomplete lifecycle group, the stages are egg, nymph and adult. In this group, the nymph looks very similar to the adult, however smaller and without wings. In addition, the feeding methods are often identical to the adults.

In the complete life cycle group, the stages are egg, larvae, pupa and adult. In this group, the larva appears distinctly different than the adult life stage.

Incomplete Life Cycle Example

(hairy chinch bug)

egg | 1st instar | 2nd instar | 3rd instar | 4th instar | 5th instar | shortwing adult | normal wing adult

Egg Stage | **Nymphal Stage** | **Adult Stage**

Complete Life Cycle Example

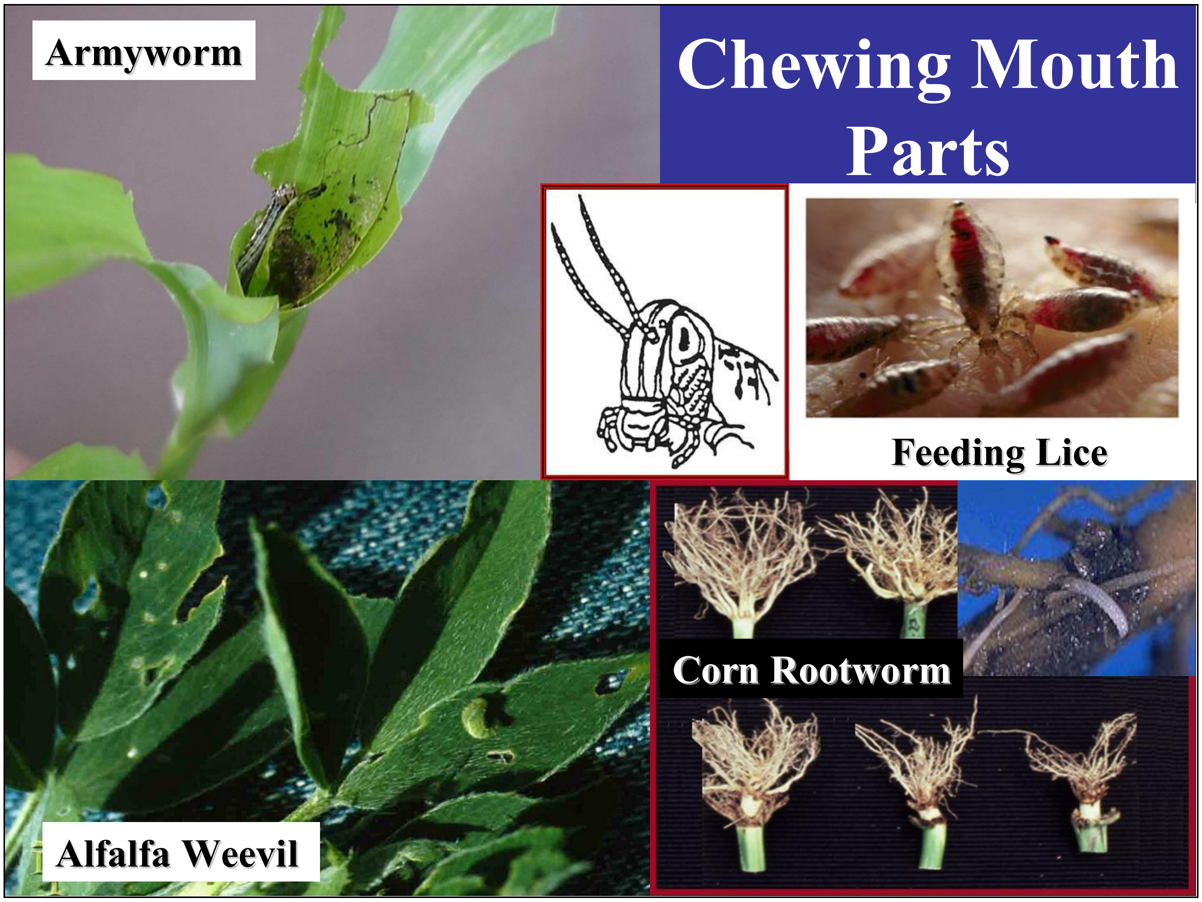
(northern masked chafer)

egg | 1st instar | 2nd instar | 3rd instar | pupa | adult

Egg Stage | **Larval Stage** | **Pupal Stage** | **Adult Stage**

Insect Feeding is also divided into two distinct types and entire groups of related insects (Orders) have similar mouth parts. The two feeding types are 1) Chewing mouth parts and 2) Piercing and sucking mouth parts.

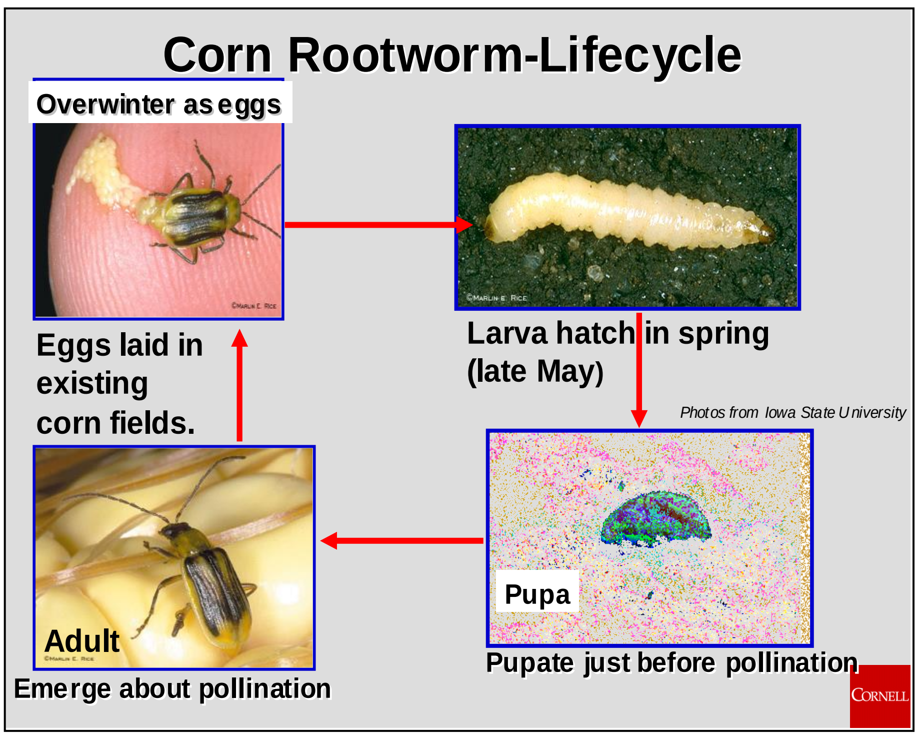
Chewing mouth parts remove solid tissue from the host and the tissue is ingested and utilized. A series of examples are shown below.



Piercing and sucking mouth parts remove fluid from the host in modified mouth parts which operate like a hollow needle. Often saliva is injected prior to feeding to breakdown cell walls and to start the digestion process before the fluid is ingested by the insect. The saliva left behind is frequently the cause of the feeding symptoms from the insect.

Insects important to field crop production in New York and the Northeastern US.

Western/ Northern Corn Rootworm:

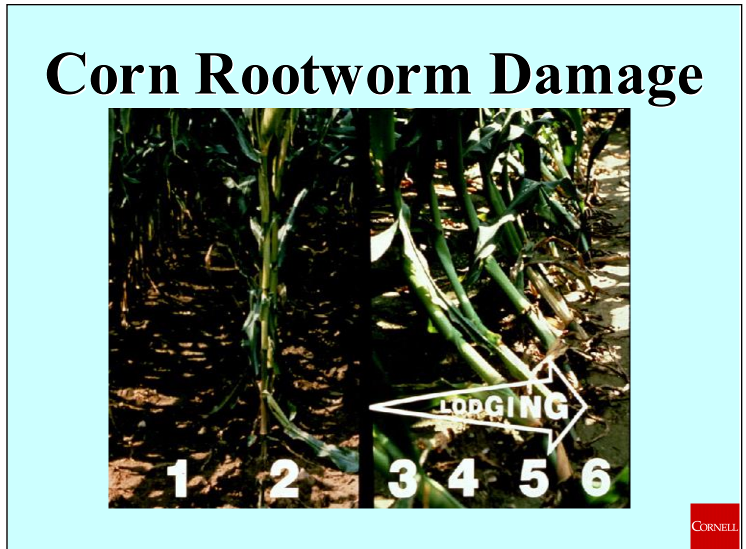


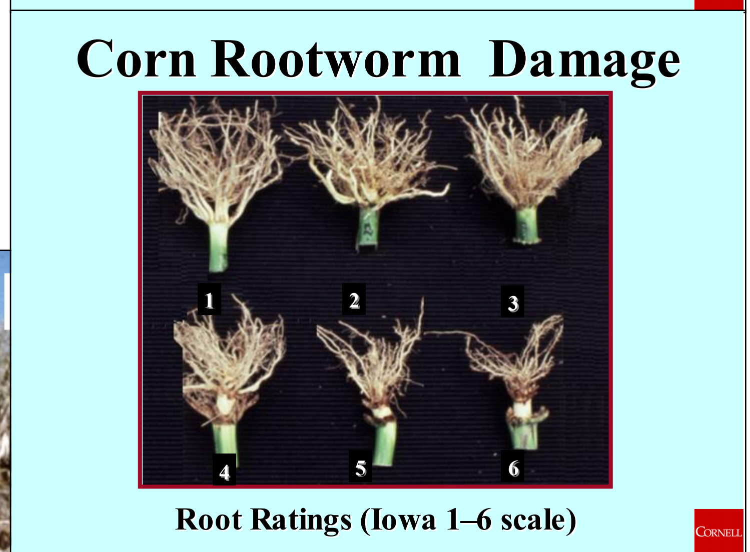
Pest Type: Primary pest

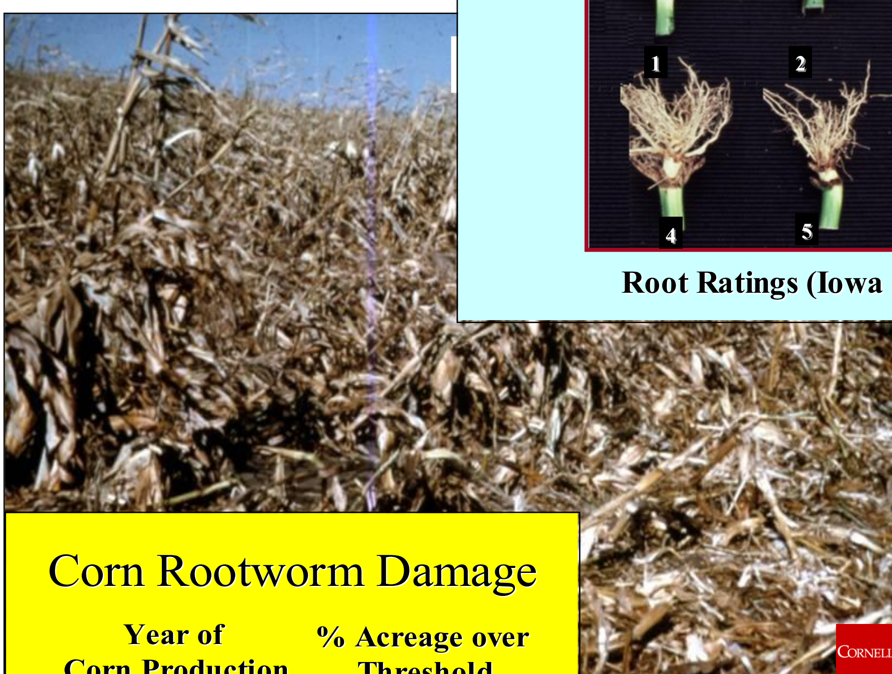
Feeding Habit, Host Range, Injury Type, Symptom, Damaging Stage:

Lifecycle:
Adults lay eggs in soil cracks in existing corn fields during August and early September. Eggs over winter in the soil until mid-May the following spring. Eggs hatch over about a 4 week period from mid-May until early June depending on the soil temperatures. Newly hatched larvae must find a corn root within 24-48 hours in order to survive. Newly hatched larvae are also prone to drowning if heavy rains waterlog the soil during this time period. Larvae feed on corn roots until mid-July in most locations. Mature larvae pupate in the soil and emerge as beetles in synchrony with pollination. Adults feed on pollen and leaf tissue during the 3-week period required for mating and egg production. Eggs are laid in the soil cracks around the base of corn plants during August and September until the killing frost with most of the eggs laid prior to September 1.

The primary host range of this insect is corn, including both field corn and sweet corn. The primary damaging stage is the larvae in the soil, feeding on the roots of the corn plant. Feeding larvae with their chewing mouth parts consume and clip off roots, interfering with the uptake of water and nutrients. Brace roots are also fed upon, causing the plant to tip over and lodge. Maximum larval damage and plant lodging usually occurs around or shortly after pollination when the plant is undergoing grain fill. Economic losses from this insect are both reduced yield from plant stress during grain fill and harvest losses from lodged plants failing to be harvested by the silage chopper or combine.







Corn Rootworm Damage

Year of Corn Production	% Acreage over Threshold
1	0
2	25-35%
3	50-70%
4	80-100%
+	

Since eggs are laid in August in existing corn fields, the risk of an economic rootworm population increases the longer a field is planted to continuous corn.

Based on the insect lifecycle, first year corn is seldom at risk under the current situation in NY and the NE US. In the Midwest corn belt, where annual rotation of corn and non-host crops have been the widespread agricultural practice, rootworm has adapted with extended diapause (hibernation) crossing more than one year and a behavioral adaptation where eggs are laid in soybean fields rather than in corn fields. These strains are not currently found east of Ohio and pose little risk under the current agricultural production practices. As noted below, second year corn has increased risk over first year corn and the risk increases as the years of continuous corn rise.

Impact of Environment on Population Dynamics:
Since this insect has only one generation per year, environmental impacts are focused sole on the effect on the single generation, not the impact on the number of generations per year as with other insect pests. Water saturated soils during the larval hatching period (late May-early June) causes a high level of mortality to the young larvae, often resulting in a sub-economic population. Droughty soils, during the hatching period, can also cause high larval mortality to the newly hatched larvae in search for the first corn root. Once a root has been located, dry soil conditions have little impact on the larvae. High soil temperatures can speed up larval development, resulting in an earlier adult emergence in July.

Impact of Environment on Crop Damage:
Since the larval feeding removes roots critical to the pollination and grain filling phase of corn production, dry soil conditions increase the impact of root removal through increased water stress to the plant. The increased water stress is often reflected in reduced grain yields. In growing seasons with adequate soil moisture during the grain filling phase, the impact of root removal is lessened because the plant is able to regenerate roots and recover from the rootworm feeding damage.

Management:
Corn rootworm populations are managed by managing the larval populations. This is accomplished by removing the food source (rotation) or killing the larvae before damage with a soil insecticide (granular or seed treatment) or a genetically modified corn plant where the rootworm active toxin is incorporated into the genome of the corn plant and expressed in the root tissue. Since this insect has a documented ability to adapt to toxins by developing resistance, attention needs to be paid to resistance management strategies to preserve the effective technologies and reduce the probability of resistance development.

Insects important to field crop production in New York and the Northeastern US.

<u>European Corn Borer</u>

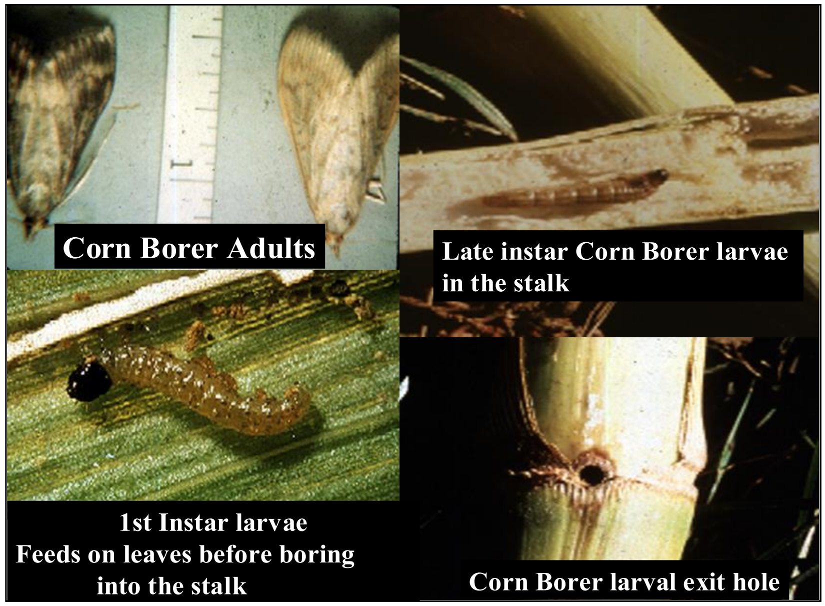
Pest Type: Secondary Pest Status in NY, Primary Pest Status in portions of the Midwestern Corn Belt.

Feeding Habit, Host Range, Injury Type, Symptom, Damaging Stage:

There are three different bio-types of European Corn Borer in New York. Biotype 1 has only a single generation per year and primarily attacks either field or sweet corn. Biotype 2 has two generations per year and primarily attacks either field or sweet corn. Biotype 3 has two generations per year and attacks a wide array of plants including corn, wheat and peppers.

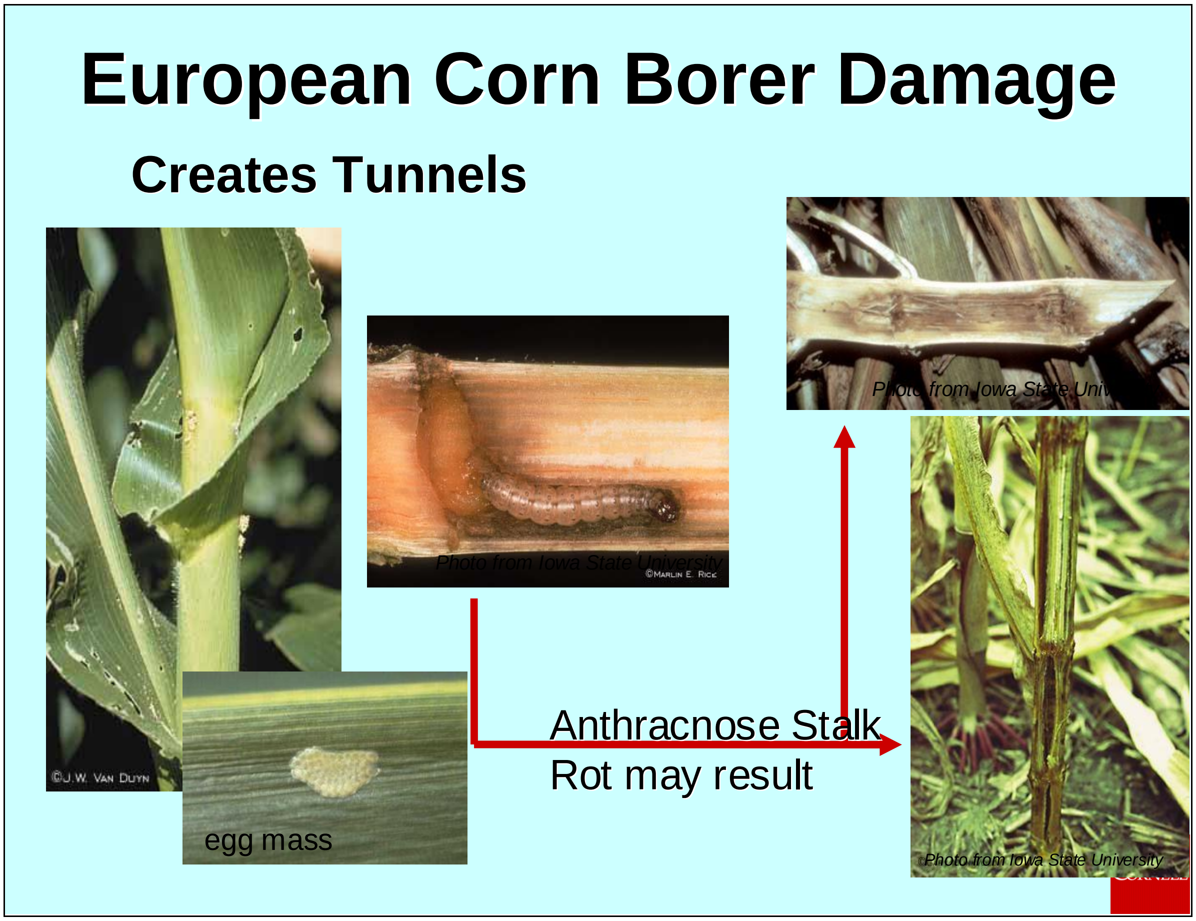
Lifecycle:
Mature larvae overwinter in the corn stalks left in the field after harvest. During the early spring, these larvae pupate and become moths which chew out of the stem and emerge during late May and early June. After mating, the females lay eggs in masses on the underside of corn leaves (1st generation) near

the midrib. After hatching, larvae feed for a short period on the corn leaves before migrating into the whorl where they bore into the stem where the remainder of larval development is completed.



In the single generation biotype, these larvae remain in the corn stalk until the following spring when they emerge as moths. In the two generation per year biotypes, the first generation larvae pupate and emerge as moths in late-July. After mating, the female moths lay eggs around the developing ear. After hatching, the newly emerged larvae bore into the ear and ear shank where they develop. After maturity, the second generation larvae remain in the corn plant throughout the winter and emerge the following spring.

All economic feeding damage is caused by the larval stage feeding on the plant and fruiting structures. Since the larvae have chewing mouth parts, the feeding damage is direct tissue removal of the leaves, boring into the stem of the plant and feeding on the reproductive portions of the plant. Economic losses result from reduced yield, damaged fruits and the introduction of fungal rots into the feeding wounds and entry holes into the plant stems.



Impact of Environment on Population Dynamics:
Since eggs are laid on the underside of the leaves and the young larvae feed on the leaf surfaces before boring into the plant, hot dry conditions cause a high larval mortality among small larvae before they bore into the stem of the plant. Since these small larvae move into the corn whorl to bore into the plant, a timely rain storm which fills up the corn whorl also causes mortality to the individuals located in the whorl. Higher temperatures during the growing season will accelerate insect development but the insect will not add an additional generation during the hot years because overwintering diapause (hibernation) is triggered by the decreasing day-length during August when the second generation is developing in the stalk.

Impact of Environment on Crop Damage:
Stalk feeding and ear feeding by corn borer larvae weaken the stalks and the ear shanks causing stalk breakage and ear drop prior to harvest. Damage is increased by strong winds in late summer and early fall before harvest. Yield can be impacted by the severing of the vascular bundles within the stalk during boring and feeding, interfering with the movement of water and photosynthesis. Crop yield and standability is also impacted with the introduction of stalk rot organisms into the corn stalk through the feeding wounds caused by the larvae entering and exiting the stalks.

Management:
The only effective management of corn borer is the use of corn varieties where the corn borer effective toxin is incorporated into the plant genome and expressed into the above ground portions of the plant. Since corn borer is a localized and sporadic problem in NY, widespread and prophylactic use of the technology is not recommended. It is recommended in situations where producers suspect a high probability of an economic problem based on historical evidence.

True Armyworm:

Pest Type: Secondary

Feeding Habit, Host Range, Injury Type, Symptom, Damaging Stage:

Lifecycle:
Armyworm is a long-ranged migrant with the overwintering area in the southern states. Migrant moths invade the northern ranges in the spring aided by the fast moving southerly winds along storm fronts. Spring migrants typically arrive between mid-April and mid-May. The magnitude of the migration into New York and the Northern Eastern US variable and is dependent on population buildup in the southern states

and the direction of the southern winds during the time of peak moth migration. In the late summer-early fall, newly emerged moths return to the southern states in a long-ranged migration utilizing the northern winds immediately following the passage of a weather low pressure front to aid their migration.

Newly arrived spring migrant moths lay their eggs in grass hay fields, grass waterways or weedy patches in last year's corn fields. Eggs hatch in 7-10 days and the newly hatched larvae feed on the grassy plants. During the larval stage, the larvae pass through 6-7 molts with each larval stage a significant increase in size. Eighty percent of the foliage consumed by the growing larvae occurs during the final larval stages. In areas where large numbers of migrant moths arrived, entire grass fields are frequently consumed and the mid-sized to large larvae start migrating to find new food sources. These mass larval movements are the source of the name of armyworm. Invading larval marches will move into adjacent corn fields, grass hay fields or other areas, feeding as they go, causing significant economic damage. These large larvae which are migrating will usually finish their larval stage within 7-10 days and enter the soil where they pupate and change into moths. The entire lifecycle during the warmer months require approximately 30 days from egg to moth.

Armyworms have 3-4 generations in the northern regions of the US, but are a significant economic problem only during the first generation in areas of concentrated migrant moth arrival and associated egg laying. Subsequent generations are low in concentration due to the migrant behavior of the newly emerged moths and the vast grassy habitats throughout the northern regions (grassy hay fields, grassy roadsides, waterways, lawns). In the fall, newly emerged moths return to the southern states for overwintering on the weather fronts with winds from the north. Armyworm does not overwinter in the northern states. Feeding damage is caused by the larvae equipped with chewing mouth parts. Feeding damage is therefore tissue removal and defoliation. Armyworm larvae feed primarily on a wide array of grasses which include all pasture species and corn. The main symptom of feeding damage is the defoliation and loss of leaf tissue. In pasture grasses, the entire blade is consumed. In the larger leaves of corn, the main leaf rib is frequently left after the remainder of the leaf has been consumed.

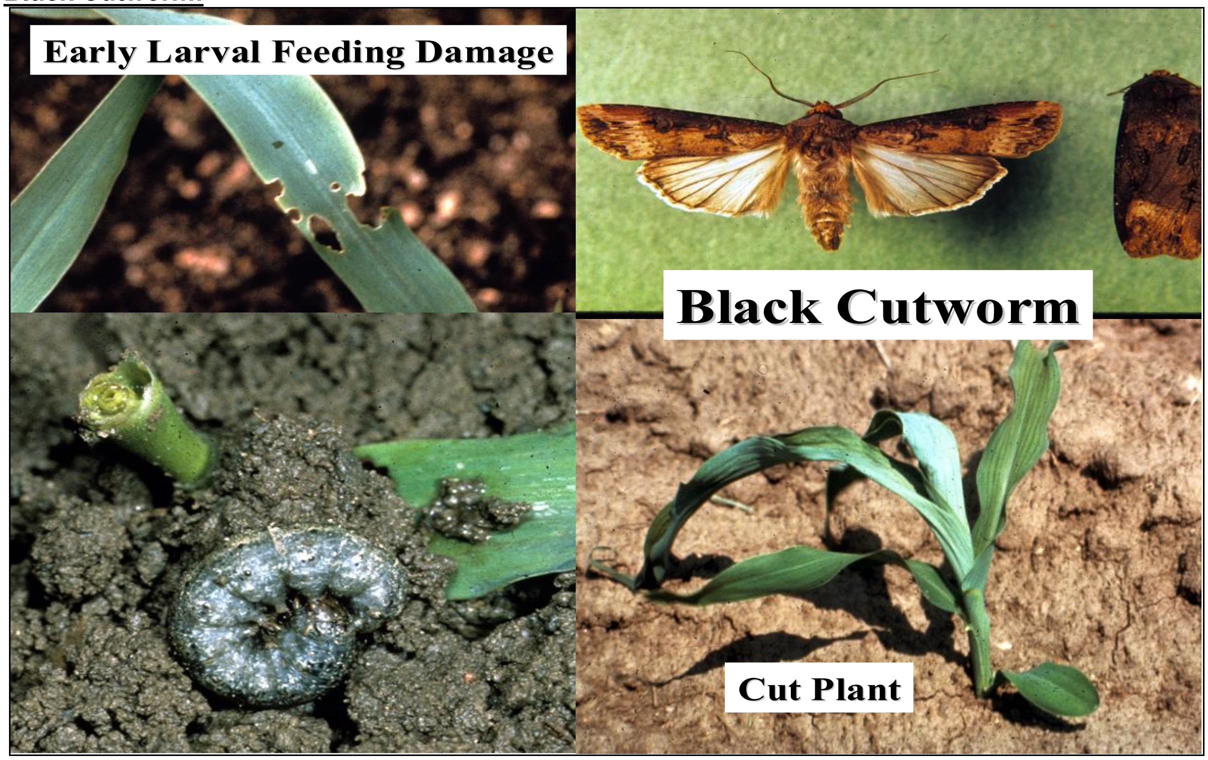
Impact of Environment on Population Dynamics:

This insect is a long-ranged migrant which does not overwinter in NY. Adults (moths) arrive on the spring thunderstorms during May and June and are deposited in large numbers in localized areas where eggs are laid in a wide range of grasses including corn. Large numbers of eggs usually result in a large number of larvae which strip grass hay fields or corn fields and move in mass to new food sources. Hence the name of armyworm. This is only a one generation early summer pest because the second generation moths disperse into the widespread grass habitats to lay the next generation of eggs and the resulting larval generation is disperse in nature.

Impact of Environment on Crop Damage: None

Management:
Effective management of armyworm problems require early detection of the armyworm larval population before large larvae are present and the armyworms begin to march due to widespread defoliation of the primary field of infestation. Typically, armyworm infestations are only detected when large larvae are present and widespread defoliation is occurring. At this point, larval feed will only continue for an additional 7 days or so and by the time insecticide is applied, the economic losses have already occurred. The total economic loss then includes the loss of crop and the cost of the insecticide with application which has limited effectiveness.

Black Cutworm:

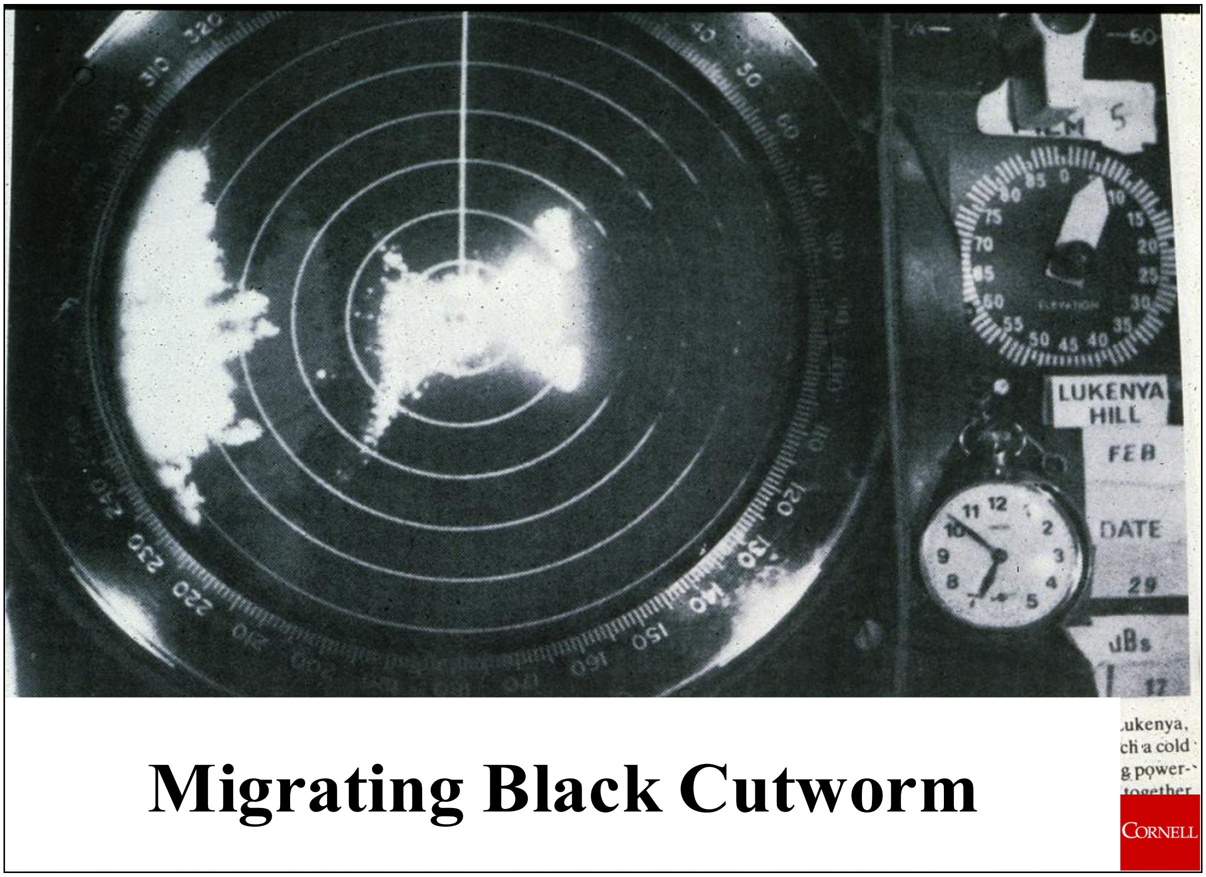


Pest Type: Secondary

Feeding Habit, Host Range, Injury Type, Symptom, Damaging Stage:

Lifecycle:
Black cutworm is a long-ranged migrant with the overwintering area in the southern states. Migrant moths invade the northern ranges in the spring aided by the fast moving southerly winds along storm fronts. Spring migrants typically arrive between mid-April and mid-May. The picture below is a radar image of migrating moths in the center of the picture and the clouds of a storm front along the left side of the picture. The magnitude of the migration into New York and the Northern Eastern US variable and is dependent on population buildup in the southern states and the direction of the southern winds during the time of peak moth migration. In the late summer-early fall, newly emerged moths return to the southern states in a long-ranged migration utilizing the northern winds immediately following the passage

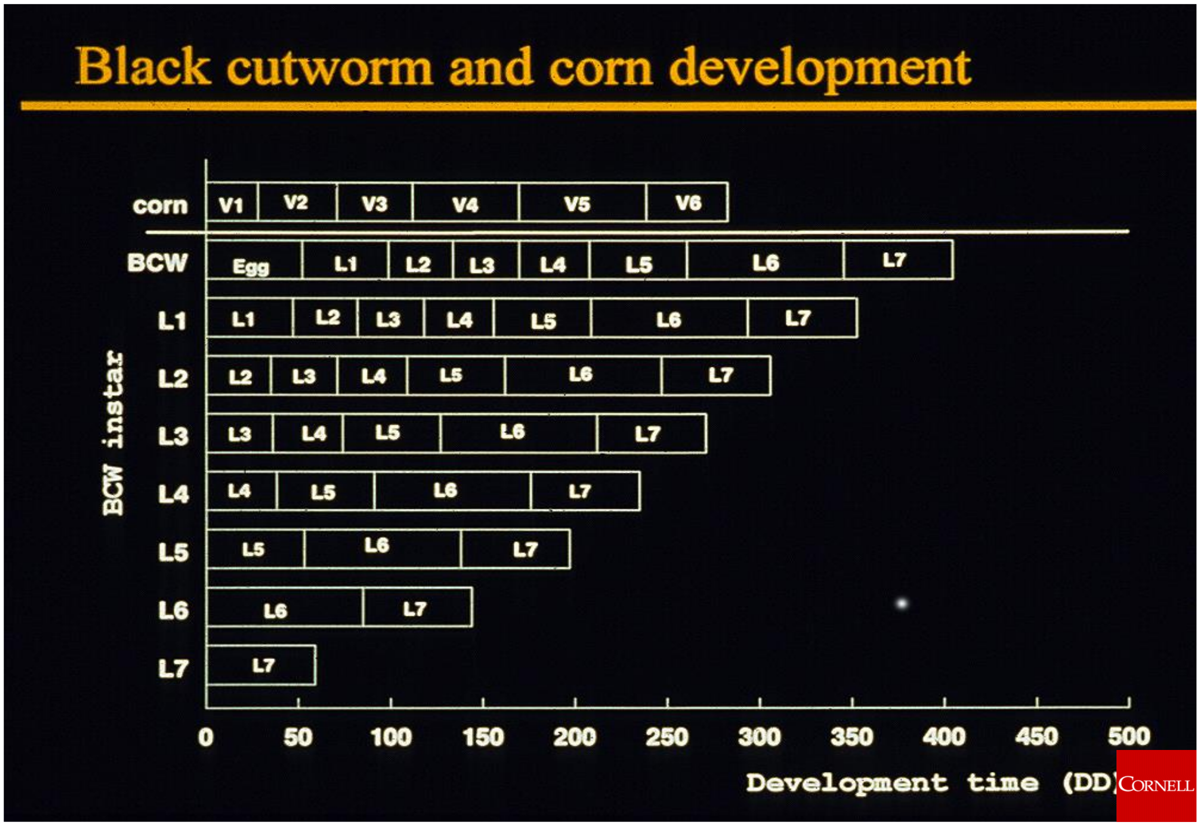
of a weather low pressure front to aid their migration. Black cutworm does not overwinter successfully in the northern tier of states.



Newly arrived spring migrant moths lay their eggs in grass hay fields, grass waterways or weedy patches in last year's corn fields. Eggs hatch in 7-10 days and the newly hatched larvae feed on the grassy plants. When the field is spring plowed for corn production, the small larvae continue to survive on the dying grass plants until the corn begins to emerge. The black cutworm larvae then move over to the young corn plants and begin feeding. The next chart shows the relationship between the development of black cutworm larvae and corn, both driven by temperature. It shows that if black cutworm eggs were laid on newly emerged corn plants, the corn would develop past V4 where corn is difficult to cut before black cutworm larvae would develop into the cutting larval stages (L4-L7). A more typical relationship between cutting larvae and plant stage is shown in the pictures with corn and larvae. The plant is V3 to V4 and the larvae is L6. According to the chart, the larvae would have been in the field as small larvae (L3-L4) when the corn plants emerged. These small larvae were surviving on dying grassy weeds when the field was plowed or killed with herbicide until the newly planted corn emerged.

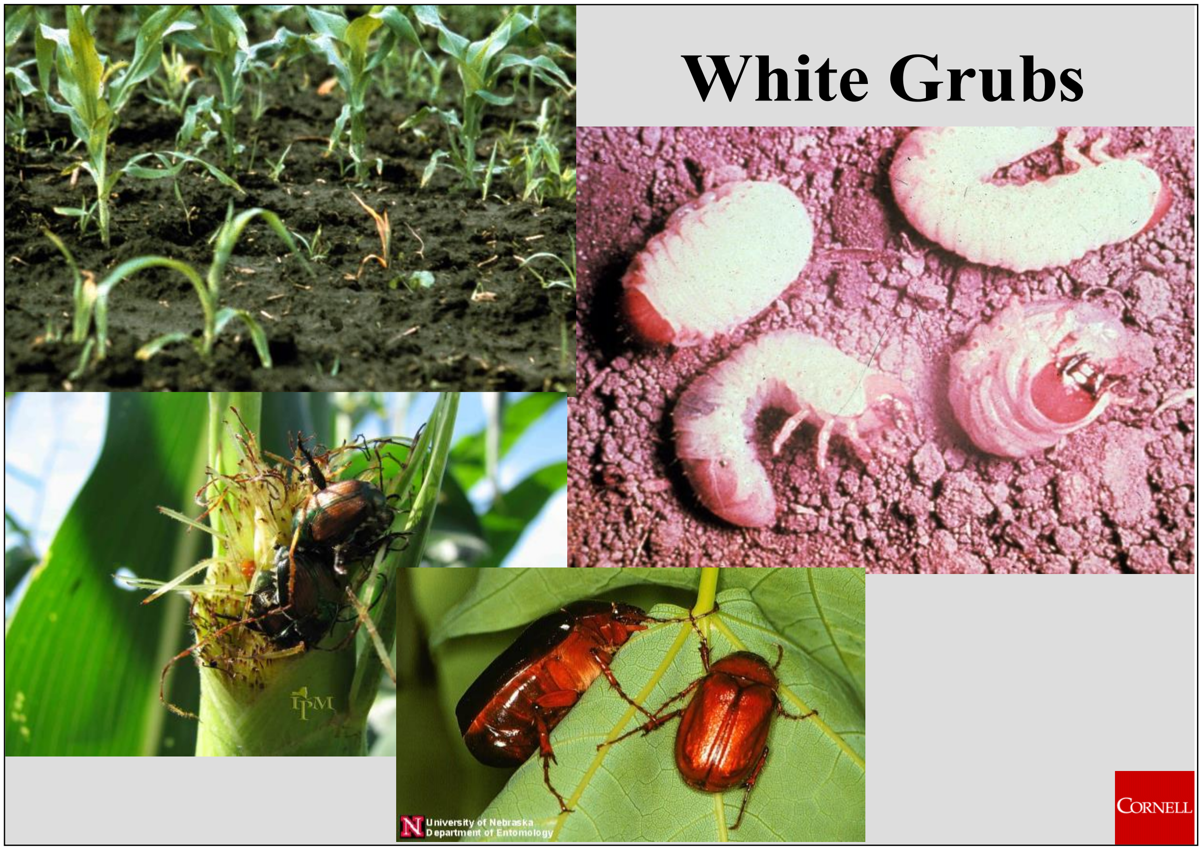
During the first half of the black cutworm larval stages (instars 1-3), the larvae remain on the plant and feed on the leaf margins. This feeding damage looks very similar to feeding damage by armyworm. However, when the larvae molt into the fourth larval instar, the larvae leave the plant during the daylight hours and hide around the base of the plant. At this time, plant cutting begins and continues for the remainder of the larval instars (instars 4-7) (about 2 weeks depending on the temperature).

Impact of Environment on Population Dynamics and Crop Damage:
Insect development is driven by temperature. Black cutworm being a spring pest, the temperatures during spring have a direct impact on the speed of both larval development and corn development. Warm springs will have a shorter period of black cutworm damage than cooler springs. The severity of damage is directly related to the relationship of larval size (when the larvae begin to cut) and the growth stage of the surrounding corn.



Management:
Effective management requires the early detection of the smaller larval instars of the cutworm, before the larvae become large enough to begin cutting. Once cutting begins, economic losses can quickly accumulate from the damaged or killed plants. Corn has an ability to compensate for stand losses but the pattern of plant losses in important in the ability of the plant stand to compensate. If the stand losses are in patches, the surround plants are not able to completely compensate for the missing plants. In the situation of an occasional missing plant within a row, the adjacent plants have an excellent ability to compensate for the missing plant. Damaged plants pose a larger problem than missing plants since they continue to compete for sunlight, nutrients and moisture. Severely damaged plants are delayed in maturity sufficiently that maturity may not be completed by killing frost in the fall, causing economic yield and quality losses.

White Grub:



Pest Type: Secondary

Feeding Habit, Host Range, Injury Type, Symptom, Damaging Stage:
There are many species of white grubs (June beetles) which are found in NY and the North Eastern US which feed on grass roots and can become a pest of both corn and grass pastures. The array of native white grubs have a 2-7 year lifecycle where the larvae feed underground for several years. In established grass fields, a wide array of larval sizes indicate that the white grub population is of the native species variety. In contrast, if all of the larval stages are very similar in size, it suggests that the white grub population is mainly comprised of the imported annual white grub species (Japanese Beetle, European Chafer).

Annual White Grub Lifecycle:
Adult beetles emerge in June (thus the name of June Beetle), mate and begin laying eggs during July in existing grassy environments. These areas range from lawns and grassy areas along roads to grassy hay fields. Eggs hatch in late July and the small larvae begin feeding on grass roots. Root feeding continues until fall when the cooling soil temperatures trigger the grubs to move deeper in the soil to below the frost line for overwintering. The larvae at this point are 0.5-0.75 grown. After passing the winter months deep in the soil, the larvae move back up to the top soil layers in the following spring to resume their feeding. It is the spring feeding by large larvae which cause the most significant feeding damage on the grass roots. Larval development is completed in late May to early June when the larvae pupate and the adult beetles emerge in mid-late June.

Multi-year White Grub Lifecycle:
The lifecycle of the multi-year white grub species is very similar but more protracted and less synchronized. Summer adult emergence and egg laying extends over a longer period and the larval stage requires multiple years to develop in the soil.

Importance of Lifecycle on Crop Damage:
Identification of the white grubs present in the field is important because the type of white grub present impacts the severity and longevity of the crop damage. For example, if the majority of the population of the white grubs is of the annual lifecycle variety, the damage will tend to be more severe but will usually be a single year event. In contrast, if a multi-year white grub dominates the population, the damage will tend to be less severe due to the lack of all larvae being at the most damaging stage at the same point in time but the problem will persist for a number years until the white grub population matures into adult and departs. Corn fields usually have a white grub problem when directly following a long term grassy sod. If the white grub population is of the annual variety, severe damage will occur to the corn roots when the plants are small in May-June but all feeding will disappear by late June. Second year corn in the same field will not have problems with white grub feeding. If the white grub population is the multi-year variety, root damage will occur to the corn for the entire growing season and second and third year corn in the same field will also suffer root feeding from white grubs but usually at a lower level.

Impact of Environment on Population Dynamics:
Since white grubs spend most of their life in the soil, severe problems usually occur in fields where good drainage is present. Field with down drainage seldom develop a significant white grub problem because the insects drown or suffocate when the soils become water-logged.

Impact of Environment on Crop Damage:
White grub feeding damage is the removal of roots from the plant, reducing the plant's ability to uptake water and minerals. Therefore, crop damage from root feeding is more pronounced during times of drought and low levels of soil moisture.

Management:
Effective management of white grubs requires the anticipation of a grub problem before it occurs and the deployment of an effective insecticide to prevent damage to the crop. Rescue treatments are expensive and rarely effective. With the currently available technology of soil active seed treatments, the use of these seed treatments on a regular basis effectively minimizes damage in most cases except where the white grub pressure is extremely high.

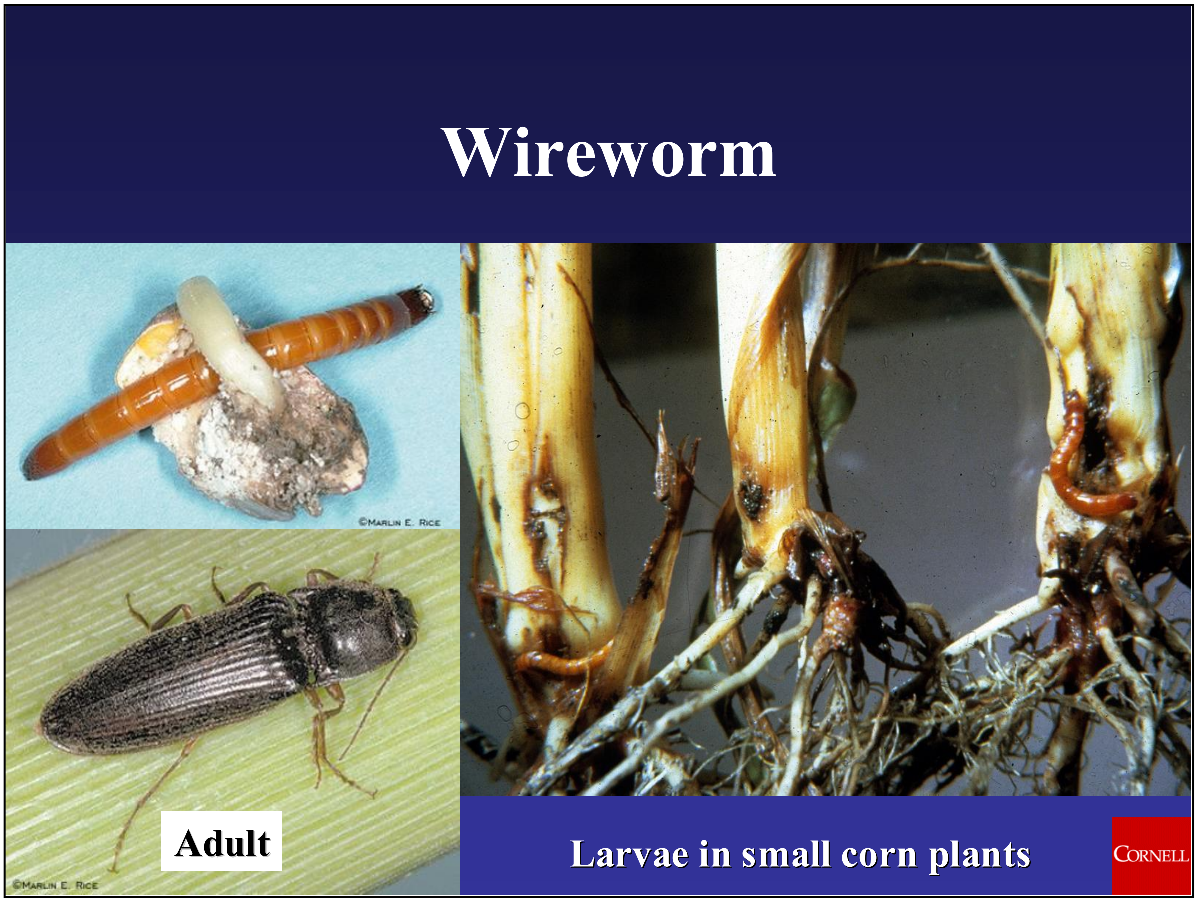
<u>Wireworm:</u>

Pest Type: Secondary

Feeding Habit, Host Range, Injury Type, Symptom, Damaging Stage:

Lifecycle:
Wireworms are native to North America and there are a number of species present throughout NY and the NE US. These species have a multi-year lifecycle with the larvae living in the soil for more than one year developing on plant roots, primarily grass roots. The adults (click beetles) typically emerge in early summer to mate and lay eggs in grassy areas such as lawns, grassy hay fields and roadsides. These

eggs hatch and larvae feed on primarily grass roots for 2-7 years depending on the species. Immature larvae move down in the soil profile in the fall, below the frost line to overwinter. As soils warm in the spring, these overwintering larvae move back into the plant root zone to resume feeding. Problems in corn are usually noted after rotating land into corn after long-term sod and wireworm problems are more prevalent in well drained fields compared to down-drainage fields. Wireworms can also become a problem in crops such as wheat which are grown in a non-rotational system.



Impact of Environment on Population Dynamics:
Since wireworms spend most of their life in the soil, severe problems usually occur in fields where good drainage is present. Field with down drainage seldom develop a significant white grub problem because the insects drown or suffocate when the soils become water-logged.

Impact of Environment on Crop Damage:
Wireworm feeding damage is the removal of roots from the plant, reducing the plant's ability to uptake water and minerals. Therefore, crop damage from root feeding is more pronounced during times of drought and low levels of soil moisture.

Management:
Effective management of wireworms requires the anticipation of a wireworm problem before it occurs and the deployment of an effective insecticide to prevent damage to the crop. Rescue treatments are

expensive and rarely effective. With the currently available technology of soil active seed treatments, the use of these seed treatments on a regular basis effectively minimizes damage in most cases except where the wireworm pressure is extremely high.

Corn Leaf Aphid:
Corn leaf aphid is not generally a problem on corn grown in NY or the NE US.

Fall Armyworm:
Fall armyworm is generally not a problem in NY and NE field crop production. It can be present and invade late season sweet corn. It is a long-range migrant similar to true armyworm except the moths tend to migrate northward in mid summer. Important to know the distinction between Fall Armyworm and True Armyworm which is the more important economic pest.

Slugs:

Pest Type: Secondary

Feeding Habit, Host Range, Injury Type, Symptom, Damaging Stage:
While slugs are not insects, being invertebrates they become the domain of entomologists. Slugs are related most closely to snails. They feed by rasping off leaf tissue with mouth parts. There are a number of slug species throughout the northern US and they feed on a wide range of plants. Slugs become an economic pest in fields with enough trash on the soil surface to provide hiding places during the daylight hours. In addition, populations increase during periods of high moisture and cloudy days. In corn fields, problems are usually noted during cool springs when the corn is small, large amounts of trash are left on the soil surface and weather conditions are cool and damp. In most cases, corn will grow out of slug damage when weather changes to the more typical warmer, dryer conditions.

Management:
There is no economically effective management tool for slug problems once they develop. In fields with chronic slug problems, soil management practices which minimize the amount of crop debris on the soil surface will minimize any slug problems in most springs.

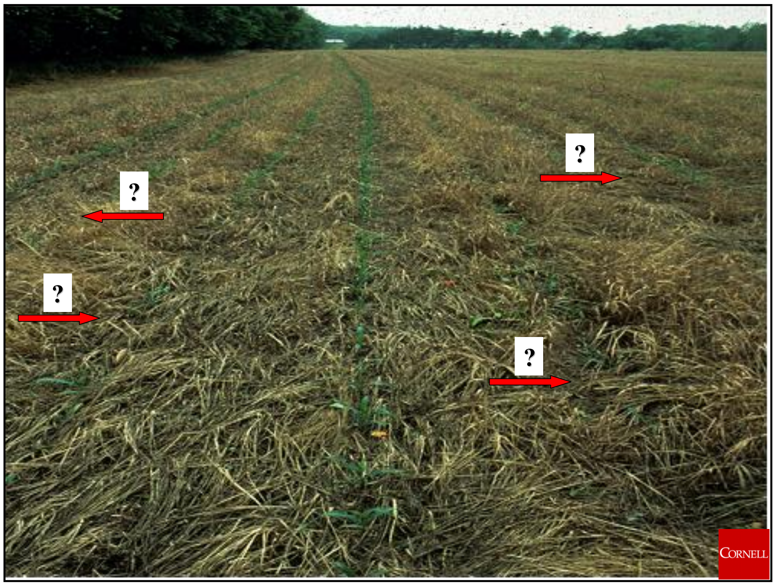
Seedcorn Maggot:

Pest Type: Secondary

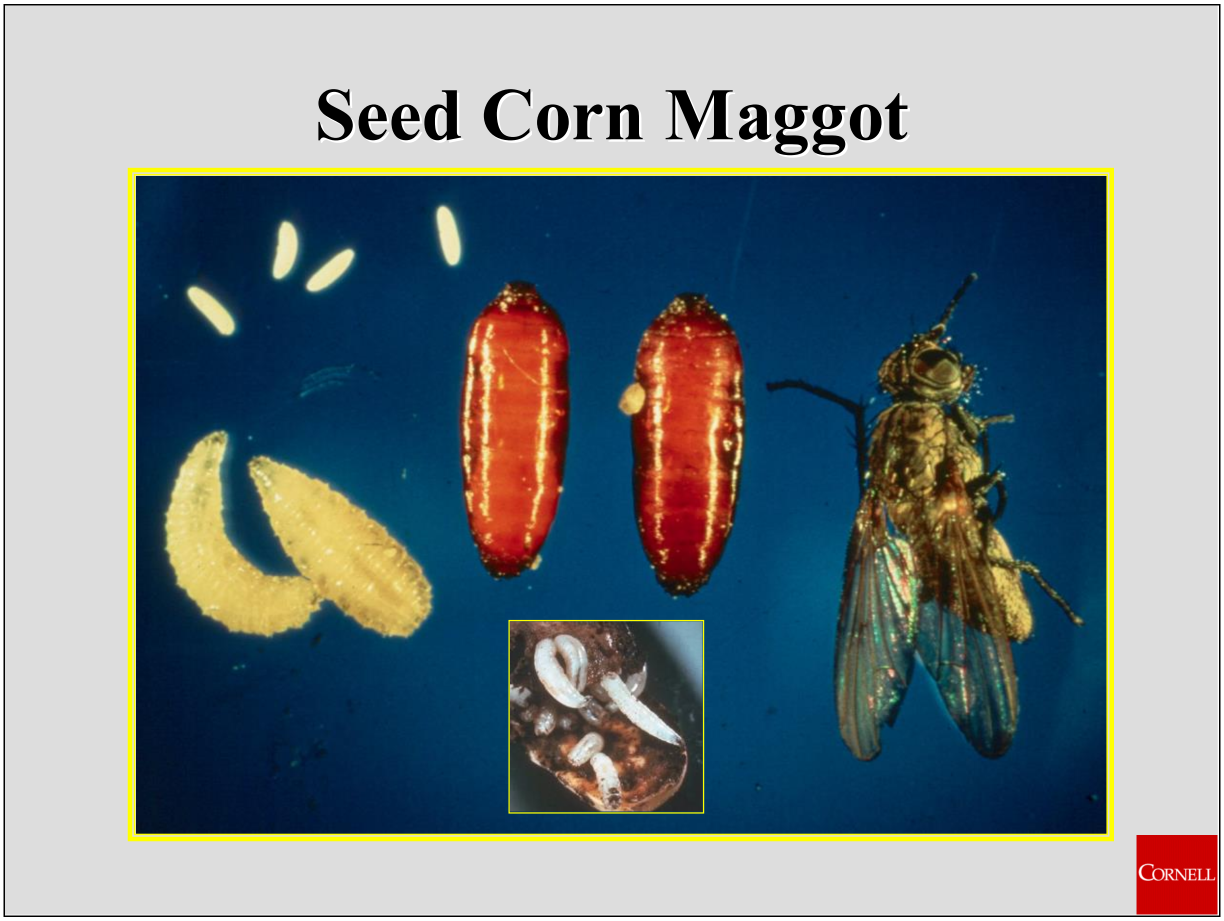
Feeding Habit, Host Range, Injury Type, Symptom, Damaging Stage:

Seed corn maggot is an introduced insect and a pest of seedlings. The larval feeding from this insect causes a reduction in plant stand. Although this insect attacks all germinating seeds and young plants, the impact is most significant on large seeded crops such as corn, soybeans and beans of all types. This insect has multiple generations per year but is only economically important in agriculture during the months of May and June when crops are being planted and germinating.

Lifecycle:
Adult seed corn maggots (flies) emerge in late April-early June from overwintering puparia in the soil. After mating, the female flies fly close to the surface and lay eggs in areas of decaying organic matter, dying plants and/or germinating seedlings. After hatching, the larvae feed on the organic matter, plant seedlings and germinating seeds. Damage to agricultural crops is expressed as skips in the plant stand where seedlings were killed before emerging and damaged seedlings which may die after emergence.



Damaged emerged corn seedlings typically have numerous holes in the leaves after the leaves have unrolled. Damaged soybean seedlings (and other beans) typically have just the stem with no leaves (snake heads). These headless stems die after emergence due to the destruction of the growing point. After maturing, the larvae pupate in the soil and emerge as flies to continue the next generation. This insect has multiple generations per year but is only economically important in agriculture during the months of May and June when crops are being planted and germinating.



Impact of Environment on Population Dynamics:
Insect development is driven by temperature. Seed corn maggot being a spring pest, the temperatures during spring have a direct impact on the speed of both larval development and crop development. Warm springs will have a shorter period of seed corn maggot damage than cooler springs.

Impact of Environment on Crop Damage:
Cool springs which delay the emergence of seedlings increase the window of potential risk and damage to this insect. The longer the seedling takes to emerge, the greater chance that the seedling will be damaged by seed corn maggot. Risk is increased when planting in fields with high organic content or after recently plowed crops such as alfalfa or grass hay. A typical example of a high risk field is the field closest to the barn which receives a large dose of manure. During mid season, the missing corn plants from seed corn maggot attack in these fields can be spotted at highway speeds.

Management:
Seed corn maggot problems are difficult to anticipate and therefore all large seeded crop seeds need to be treated with a seed treatment insecticide to prevent stand losses from this insect. In corn, almost all available commercial corn seed is treated with the low rate of soil active seed applied soil insecticide which is applied for the control of seed corn maggot and other secondary pests like wireworm.

Small Grains:

Cereal Leaf beetle:

Pest Type: Primary

Feeding Habit, Host Range, Injury Type, Symptom, Damaging Stage:

Lifecycle:
Cereal leaf beetle is a pest of small grains. The adults overwinter in the field edges and enter the fields in the spring. Eggs are laid on the leaves of the small grain plants. The larvae which hatch from these eggs defoliate the plant and it is the defoliation which causes any yield losses. In most years, the introduced biological control agents hold the cereal leaf beetle populations at sub-economic levels. However, each year there localized fields reported where the cereal leaf beetle population reaches levels where the application of an insecticide may be justified to reduce the economic impact of the insect.

Management:
In most years and in most fields, the established biocontrol agents prevent the cereal leaf beetle populations from increasing to economically damaging levels. Occasionally, localized populations can exceed these levels and the application of an insecticide may be justified. However, caution should be used because insecticides effective on cereal leaf beetle also have a negative impact on the biological control agents.

Wireworm:

See corn discussion.

Soybeans:

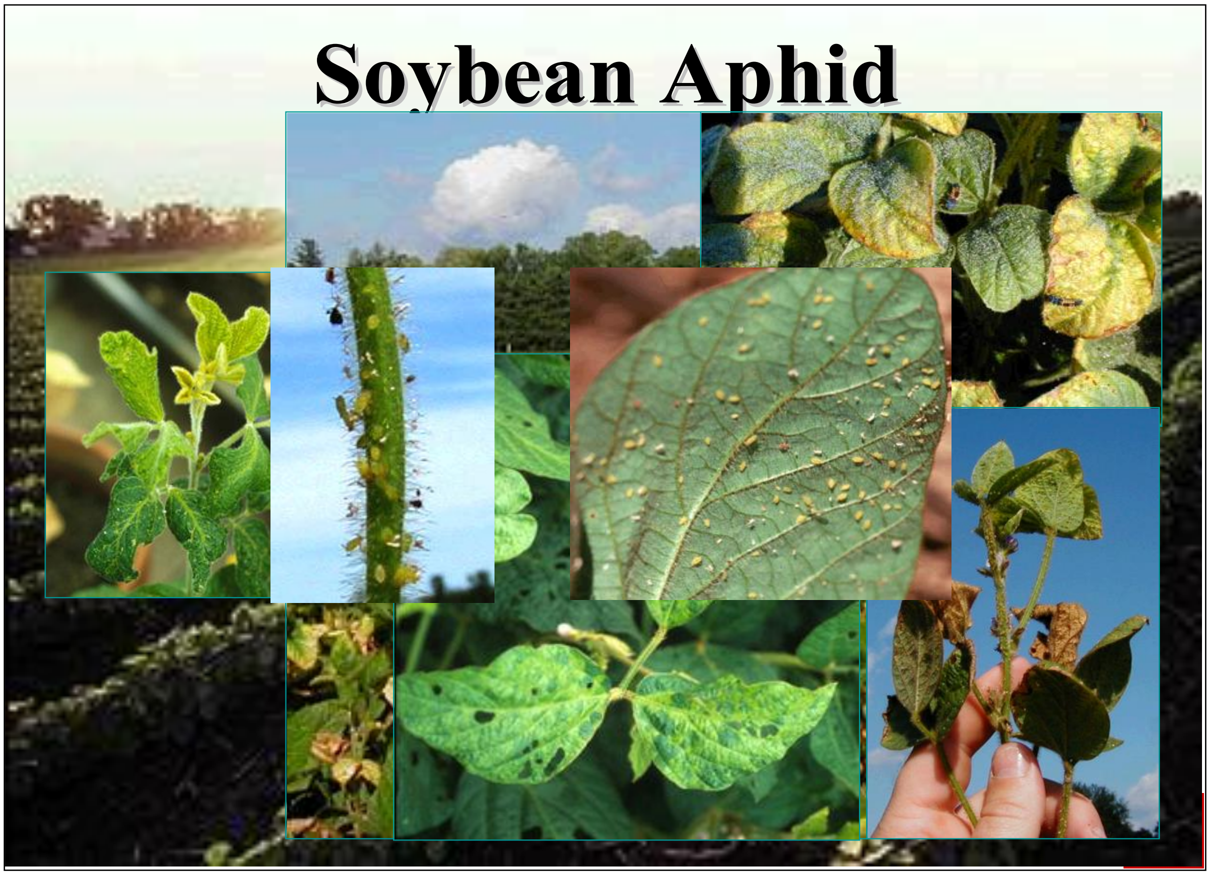
Soybean Aphid

Feeding Habit, Host Range, Injury Type, Symptom, Damaging Stage:

Soybean aphid is a recently introduced pest from the far eastern parts of the world. In some years, populations can rise to economic levels and in other years, the populations remain sub-economic. Typically, aphid populations are found in localized hot spots within fields and in localized fields within an area. Widespread infestations across a large number of fields within a region are seldom observed.

Lifecycle:
Soybean aphids overwinter on buckthorn located on field edges and on the edges of forested tracts. In the spring, overwintering eggs hatch and the first generation of aphids develop on the overwintering host. After maturity, the winged aphids leave the buckthorn and migrate into surrounding soybean fields. This first migration event is usually during mid-late May. This is local movement from local overwintering hosts and is usually a small magnitude event. A second flush of aphids usually arrive in late June-early July in correlation with summer thunderstorm activity. These aphids are long-range migrants, usually from the upper Midwestern states and can be deposited in large numbers within a localized area. In most years,

economically important aphid populations in individual fields are a result of these long-ranged migration events. Once a field is infested with the migratory winged aphids, wingless aphids are produced and the population cycles every 7-10 days, until very large numbers cause the decline of the plant quality. At this point, winged aphids are produced and the winged aphids move to other plants. In late August-early September, winged aphids are produced and these aphids leave the soybean fields and fly to the overwintering host and lay eggs. These eggs then overwinter and initiate the next year's aphid population.



Pest Type: Primary

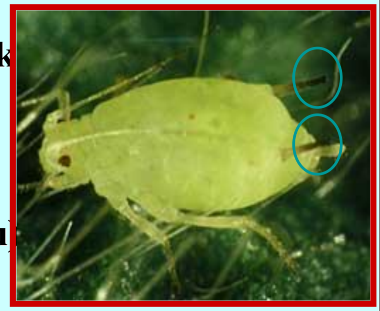
In many years, biological control agents are effective in reducing the aphid population so it remains at sub-economic levels. These biological control pressures include predation by lady bugs, lacewing larvae and widespread epidemics of the entomopathogenic fungi.

Impact of Environment on Population Dynamics:
Aphids are very sensitive to local environmental conditions. Hard rain storms wash the aphids off the plant and reduce the populations. Humid conditions encourage the outbreak of entomopathogenic fungi epidemics which quickly move through the aphid population and dramatically reduce the population. Dry periods encourage the predation by insect predators such as lady bugs.

Impact of Environment on Crop Damage:
Aphid feed removes plant fluids from the plant in significant quantities. During periods of low rain fall and droughty conditions, plant infested with aphids suffer water stress quicker than non-infested plants. The presence of long term or frequent water stress has a negative impact on plant yield.

SBA Biology and Identification

- Pale yellow aphid less than 1/16" long
- ***Only*** aphid that forms colonies on soybeans
- Black cornicles (tail pipes)
- Parthenogenic
- Populations may increase 10X /wk
- 15 - 18 generations per season
- Overwinter on Buckthorn
  (***Rhamnus*** spp),
  Pueraria phaseoloides (a kudzu)
- Wild hosts: ***Glycine spp***



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SBA Damage / Loss Assessment

- Vulnerable Soybean Stages
  - Early season infestations (V2) that peak in early reproductive growth stages (R1-R2, early - full flowering) can reduce yields by 3 - 50% depending on pest density
  - Late season infestation losses minor to undetectable, unless virus is present
- Yield impact data from US very limited
  - Economic infestations in US 2000-2002 ltd to Midwest areas
    - 13-15% yield reductions have been measured in replicated field plots in Wisconsin and Minnesota.
    - Virus potential raises concern about seed certification
    - Aphid feeding may reduce protein content restricting access to some markets

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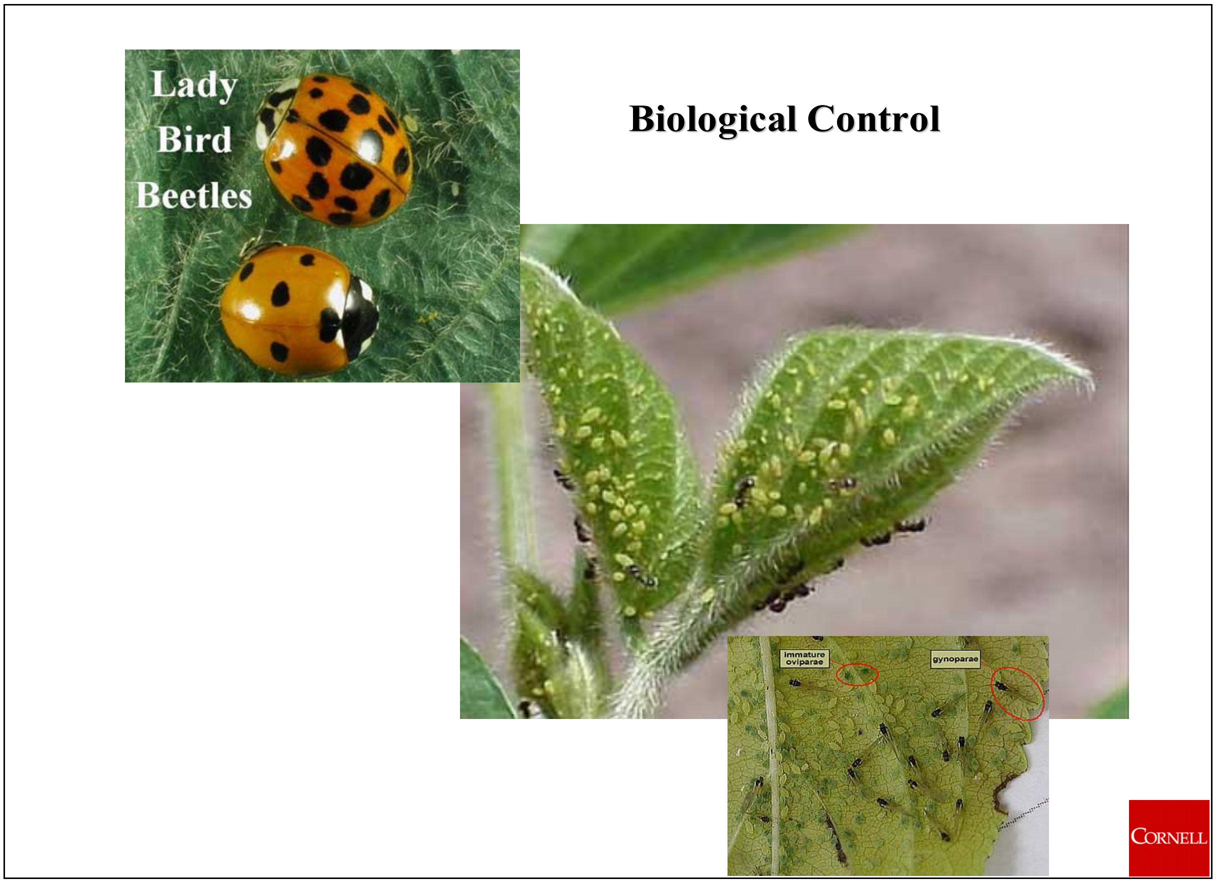


Management:
Scouting fields for aphid economic numbers is an important step before any spraying. Early spraying for sub-economic populations of soybean aphids kill off the effective biological control insect predators and allow the surviving aphids to rebound quickly. In addition, these early treatments with insecticide often trigger spider mite outbreaks in hot dry years. Controlling spider mites is a difficult tasks and the yield losses from a widespread spider mite infestation is often greater than yield losses from aphids. This scenario can be avoided by first scouting the field and only treating when the populations exceed economic levels and the plant is approaching the plant stages where aphid feeding has been documented to reduce yields.

Spider Mites:

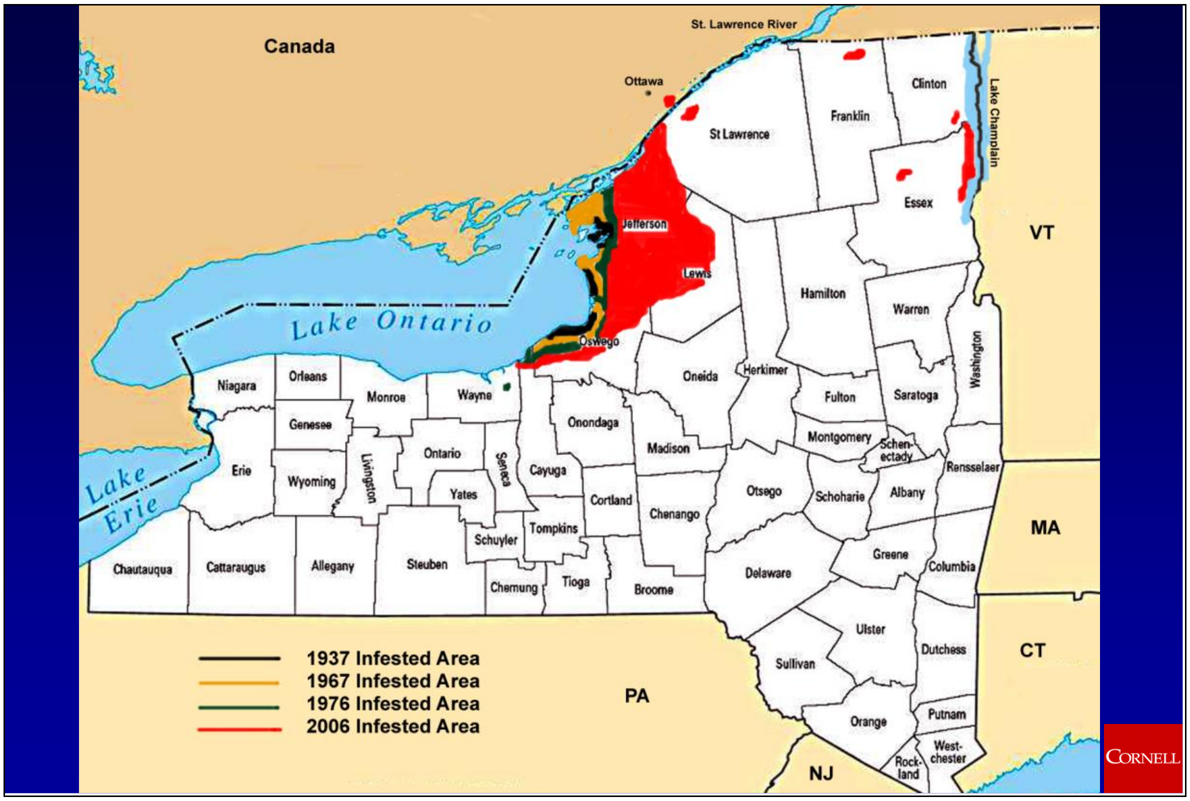
Spider mites are not generally a problem on field crops grown in NY or the NE US. In soybeans, early insecticide applications for soybean aphid, coupled with hot dry summer conditions have been responsible for localized spider mite outbreaks. If insecticide applications are delayed until actual economically important populations of soybean aphid, spider mite infestations seldom occur regardless of the summer conditions.

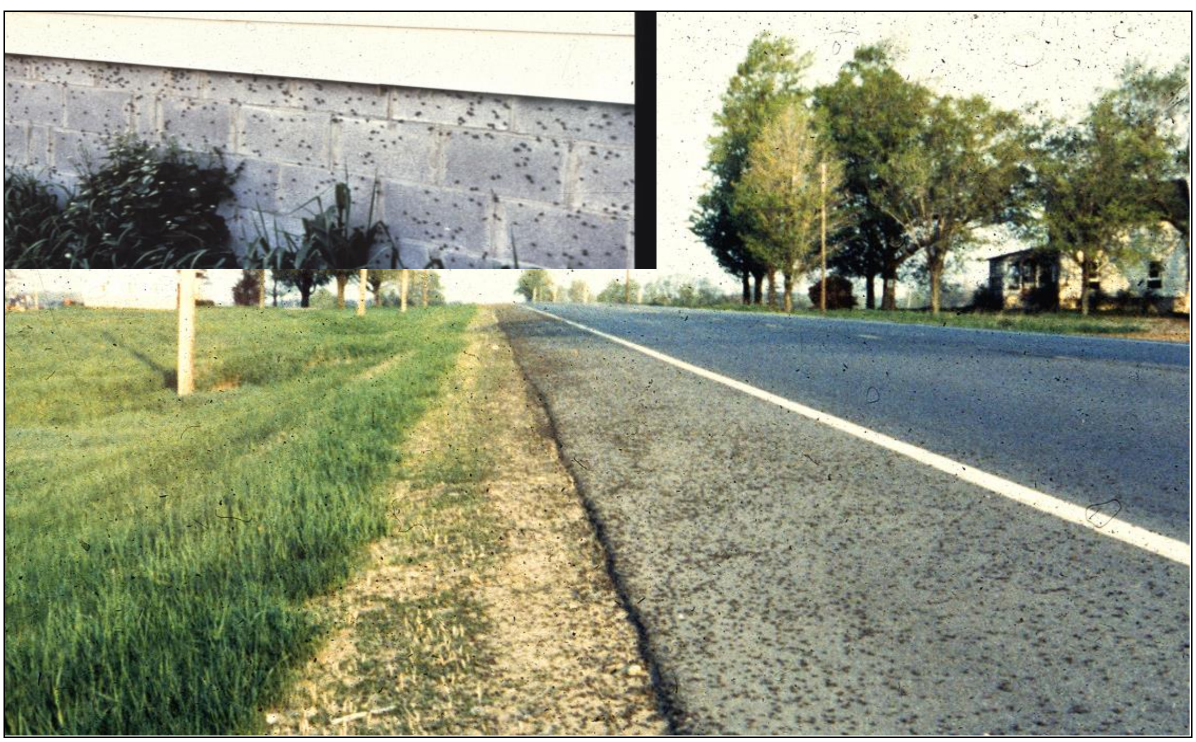
Seed Corn Maggot:

See discussion under corn.

Alfalfa:

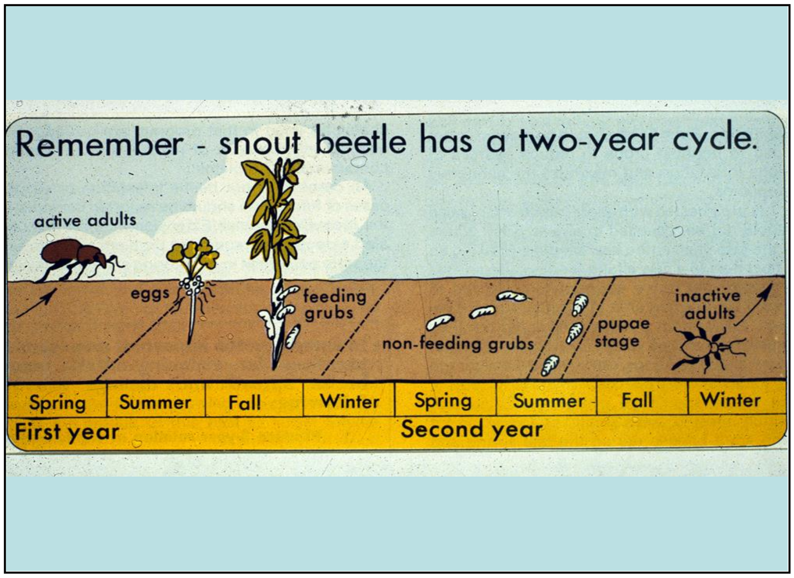
<u>Alfalfa snout beetle:</u>





Pest Type: Primary

Feeding Habit, Host Range, Injury Type, Symptom, Damaging Stage:



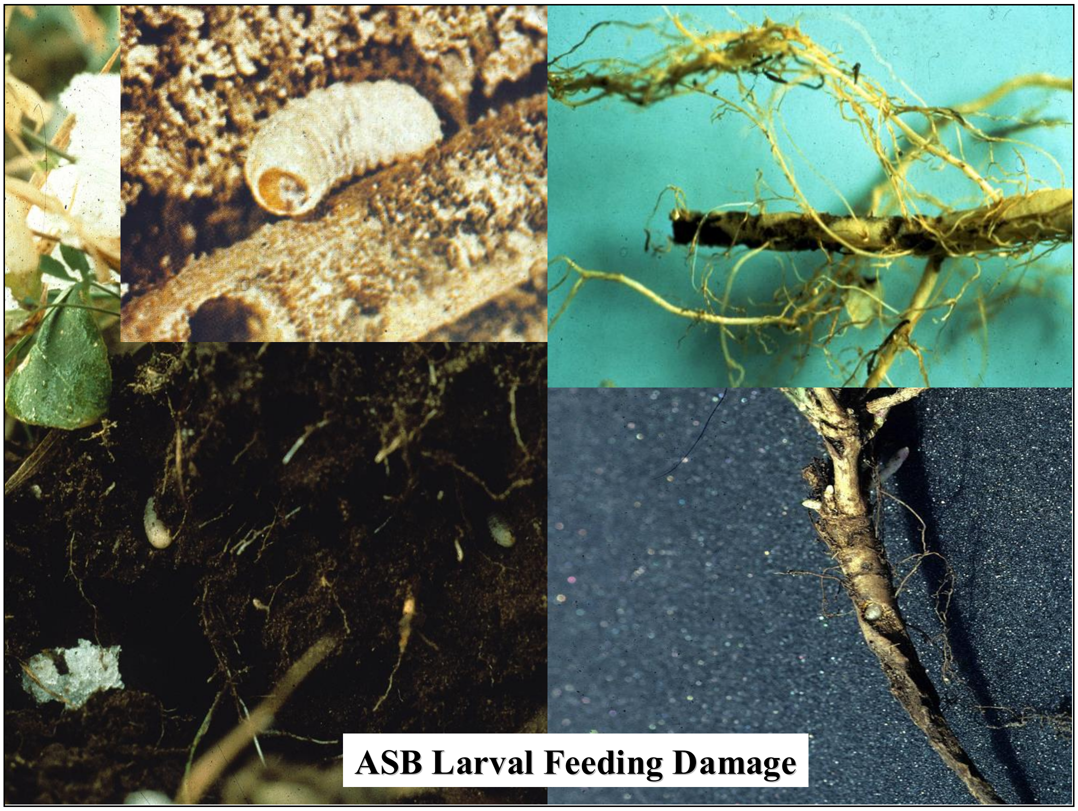
Lifecycle:
This insect has a 2-year lifecycle with most of its lifecycle spend in the soil. All development occurs during the first year and the insect remains deep in the soil in hibernation for the second year before emerging the third spring. Offspring from odd-year emerging adults will emerge as adults the following odd year (2007-2009).

Adult: All adults are females and there are no known males in the North American population. Adults emerge from deep in the soil during the first week of May and feed on the foliage of a wide array of plants. Host plants include alfalfa, clover, rhubarb, grapes and roses. After about 3 weeks of feeding, the adults begin to lay eggs around the base of host plants. Economically, the most important plants are alfalfa and clover. Oviposition continues for about 4-6 weeks with each female laying between 150-300 eggs.

Larvae: The major economic damage to alfalfa and clover is caused by larval feeding on the roots of the plant. Small larvae feed on the secondary roots causing root pruning and reduction of the root system. As the larvae grow larger, they move to the main tap root where they girdle the tap root with longitudinal spiral feeding. As the larvae enter the last two larval instars, they sever the tap root and often feed up into the interior of the tap root. Larval feeding starts in early June with the feeding on the secondary roots and the larger larvae finish their feeding with sever root damage in the fall during October and November. Plant death from root feeding damage started in late summer and continues throughout the winter. Farmers are greeted in the spring with large areas of their alfalfa fields dead and devoid of plants (pure stands) or in mixed stands with grass, a hay field composed completely of grass without alfalfa.

Fall above ground symptoms of snout beetle larval root feeding

Stand loss in the spring due to the previous year's snout beetle larval feeding.


ASB Larval Feeding Damage


2007 10 25

Impact of Environment on Population Dynamics:
Since all of the extended larval stage is spent in the soil, the larval stages have difficulty surviving in fields with high water tables and poor drainage. This insect survives best in fields with excellent drainage (natural or tiled) and will build to very high populations under these conditions. In fields with poor drainage, this insect is not the leading cause of death of alfalfa stands.

Impact of Environment on Crop Damage:
Dry soil periods during the periods of heavy root feeding increase the occurrence of plant death under droughty soil conditions. Plants surviving insect attack the previous year will often die the following year from water stress due to the severely pruned root system.

Management:
There are currently no effective management strategies for alfalfa snout beetle. For the past decade, intense research efforts have been focused on the biological control of this insect with persistent entomopathogenic nematodes and the development of resistant alfalfa varieties. Field studies are currently being conducted focused on the effectiveness of these two strategies.

Alfalfa Weevil:

Pest Type: Primary in first harvest (cutting).

Feeding Habit, Host Range, Injury Type, Symptom, Damaging Stage:

Lifecycle:

Adults overwinter in the field edges and other protected locations until the warming temperatures of early to mid April. Adults then enter the field and begin feeding on the new emerging alfalfa foliage. After a period of feeding, the females begin laying eggs in a cavity chewed in the stems of the alfalfa plant. Upon hatching, the young larvae move to the growing tip of the plant where they develop on the leaves around the growing point. As weevil larvae increase in size, their leaf consumption rate increases to the point where 80% of leaf loss occurs during the final larval stage. With moderate to high populations, the field can turn brown from this late larval feeding in a few days. This is usually called "frosting".


Alfalfa Weevil Feeding Damage

Upon completion of the larval stage, the larvae pupate in cocoons on the plant and then emerge as adults. The adults then leave the field for a summer hibernation until fall when the re-enter the fields for feeding prior to overwintering. There is one generation of insects per year and the majority of the damage is limited to the first harvest of alfalfa.

The release of effective biological control agents in North America has reduced this insect to secondary pest status. A few localized hot spots are reported each year, but the biological control agents usually respond and insecticide applications are usually unwarranted. Often an early harvest of the alfalfa prevents an economic loss from this insect. Alfalfa stands with less than 50% are not economic to treat with an insecticide.

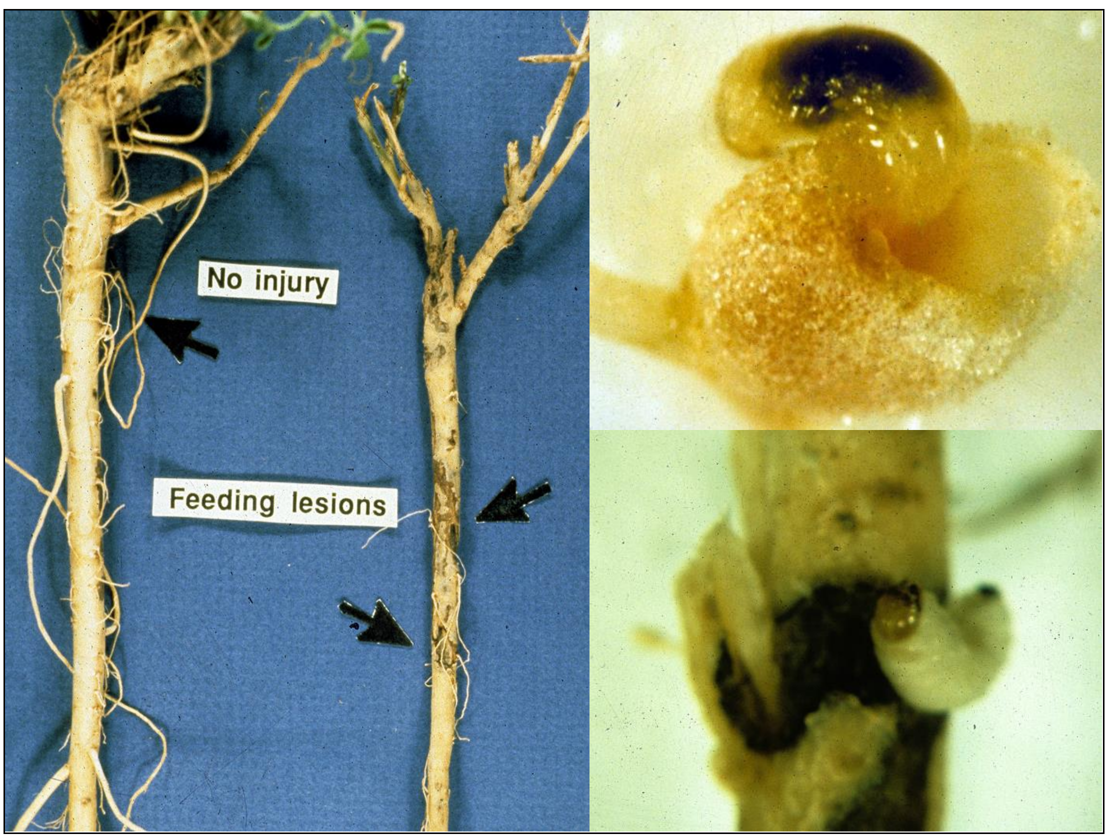
Impact of Environment on Population Dynamics and Crop Damage:
Cool wet springs are favorable to pathogenic fungi outbreaks which hold the insect in check. In addition, alfalfa has a lower temperature threshold for development than alfalfa weevil and the crop will usually be ready for harvest before alfalfa weevil reaches the economically damaging late larval instar. In these cases, early harvest is the best solution to prevent economic losses. In years when the spring conditions are warm and dry, alfalfa weevil can be an economically important pest in localized situations.

Management:
In most areas and in most springs, the current array of biological control organisms prevents this insect from resuming its past role as a major insect pest of alfalfa. Each year, reports of localized outbreaks surface but early harvest of the crop usually prevents the economic loss from this insect. In subsequent years, the biological control agents re-exert their pressure on the population and the alfalfa weevil returns to its sub-economic level. If necessary, effective insecticides are available for alfalfa weevil larval control.

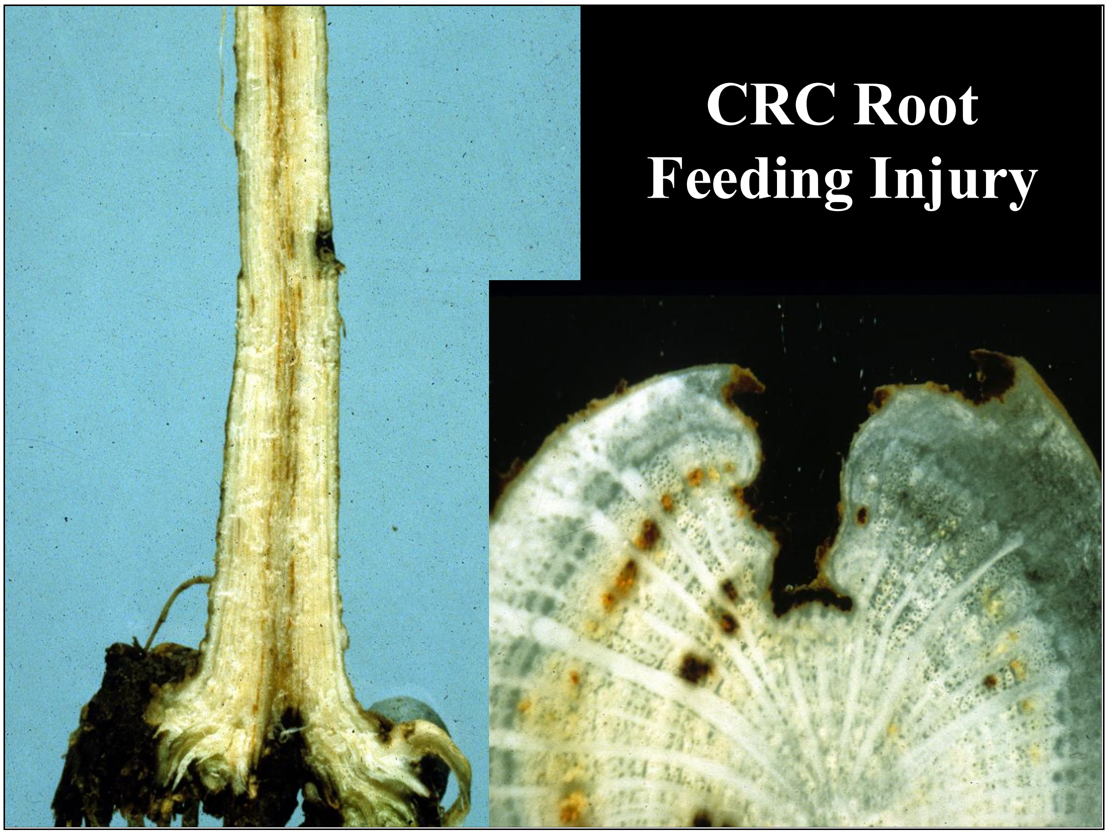
Pea Aphid:
Pea aphid, though often numerous in alfalfa fields, is seldom an economic pests. The cutting cycle of alfalfa reduces the population on a regular basis and the population does not have time to rebound to economic levels before the next alfalfa harvest.

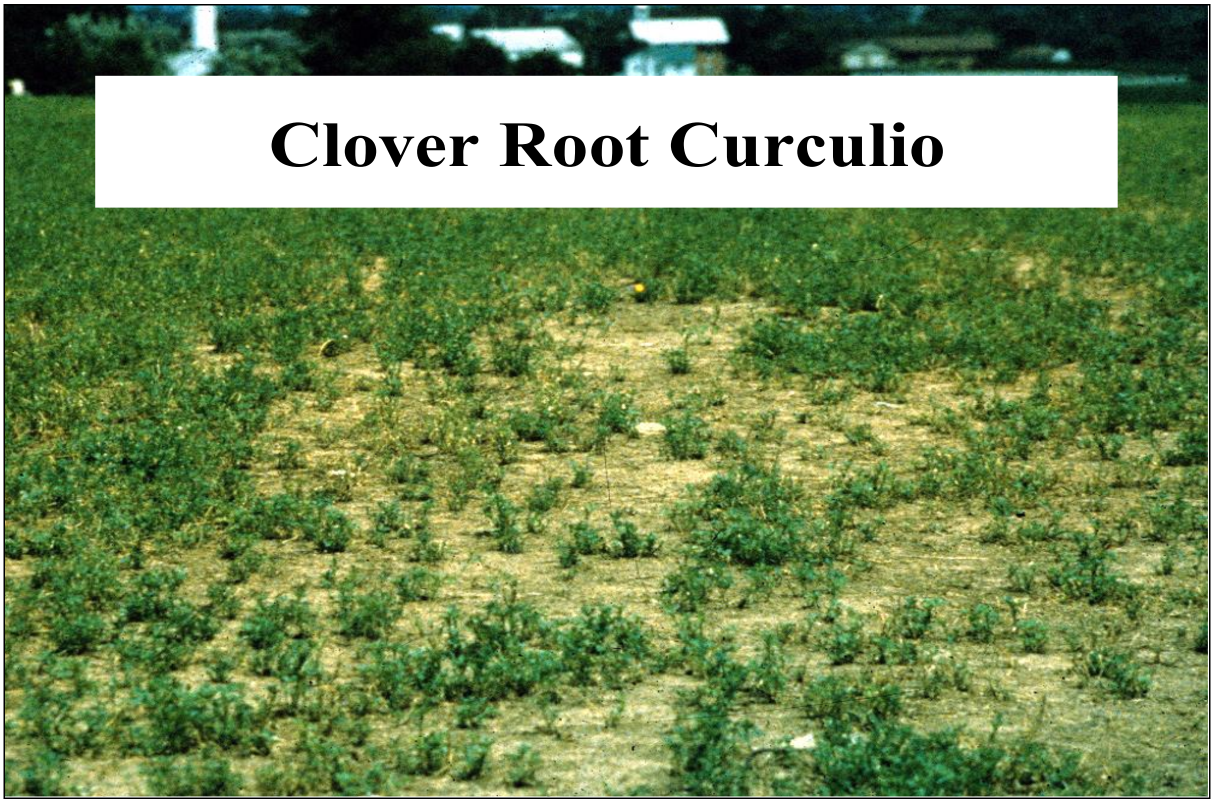
Clover Root Curculio:

Pest Type: Secondary



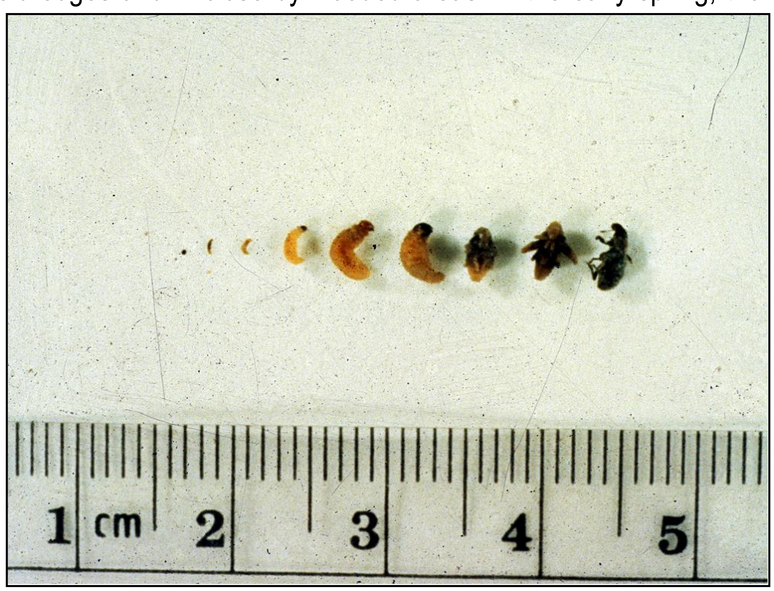
Feeding Habit, Host Range, Injury Type, Symptom, Damaging Stage:
While the adults feed on the foliage, the economic damage from this insect is the larval feeding on the plant root system. The larvae chew grooves in the roots which may girdle the roots. In addition, the larval feeding wounds provide entrance for soil pathogens to enter the root. Most plant death is from the attack by soil pathogens. The major impact of this insect is a loss of plants in the alfalfa stand and the reduction of alfalfa stand life.





Lifecycle:

The adult beetles overwinter in the field edges and in close by wooded areas. In the early spring, the overwinter adults break diapause (hibernation) and enter the alfalfa or clover fields. Usually, the adults cannot fly at this time because of the low temperatures and low energy reserves. Upon entering the field, the adults begin feeding on the foliage to build fat reserves in order to begin oviposition (egg laying). In the NE US, oviposition occurs during May. Eggs are laid on the leaves of alfalfa and clover. After hatching, the small larvae fall to the ground where they enter the soil and begin feeding on the clover or alfalfa roots. Young larvae must find a nitrogen-fixing nodule in order to survive. Larval development is completed in about 30 days and the new adults emerge from the soil. Newly emerged adults leave the field and spend the summer in protected locations in summer aestivation (hibernation). In the fall, the adults re-enter the field to feed on the foliage and lay a few eggs. Most of these eggs do not survive the winter. Adults exit the field to protected locations for overwintering.



Impact of Environment on Population Dynamics:
This insect has a single generation per year. Water logged soils during the larval stage will cause significant mortality to the larvae feeding on the roots. Otherwise, there is little known additional impact of the environment on the population dynamics.

Impact of Environment on Crop Damage:
Loss of roots reduces the plant's ability to extract water from the soil. During times of dry soils, CRC damaged plants become water stressed much sooner than undamaged plants. Persistent water stress results in loss of yield and plant death.

Management:
Currently, there are no effective strategies to manage CRC in NY and NE alfalfa. Research is underway to develop a line of resistant alfalfa, but deployment of any resistance is years away.

Potato Leafhopper:

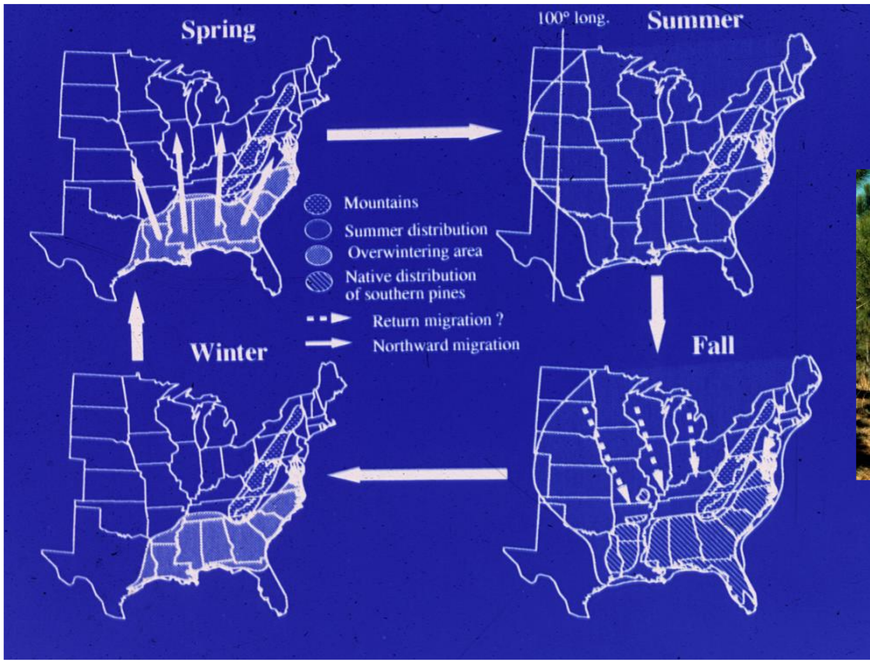
Pest Type: Primary

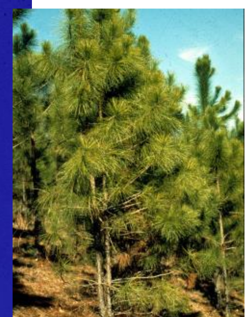
Feeding Habit, Host Range, Injury Type, Symptom, Damaging Stage:
Potato leafhopper has a host range of over 200 plant species, including alfalfa, and potatoes. Hosts also include tree species such as willows, maples and hickories. This is a migratory insect which overwinters in the southern US and arrives in the Northeastern US in the spring around Memorial Day on thunderstorms.

Potato Leafhopper in Alfalfa

Lifecycle:
In the southern US, females which have overwintered on southern yellow pines move off the pine trees around the first of March and begin laying eggs on a wide array of hosts from legumes to trees like willows and hickories. After 1-2 generations on the local hosts, the newly emerged adults migrate north on the warm southern winds during late April and early May. Spring migrants typically arrive in the upper Midwestern states around May 1 and typically arrive in Upstate NY around Memorial Day. Arriving migrant females begin laying eggs immediately on the wide array of hosts with alfalfa being the most important host to field crop production. During the growing season in NY and the NE, there are 3-4 generations. All life stages are damaging to the host with the nymphs having a greater impact because they are flightless and feed within a localized area. Plant damage is a result of the injection of a salivary toxin into the leaf tissue during feeding from the insect's piercing/sucking mouth parts. Low levels of the toxin in the leaf causes the restriction of the vascular tissue in the leaf and causes photosynthesis to shut down. A higher toxin level results in leaf yellowing, burning of the leaf margins and leaf death. Over wintering adults start departing from the NE US for their return trip to the overwintering area in the southern US in mid-August and all of the fall migrants have departed by September 10 in most years.

Potato Leafhopper

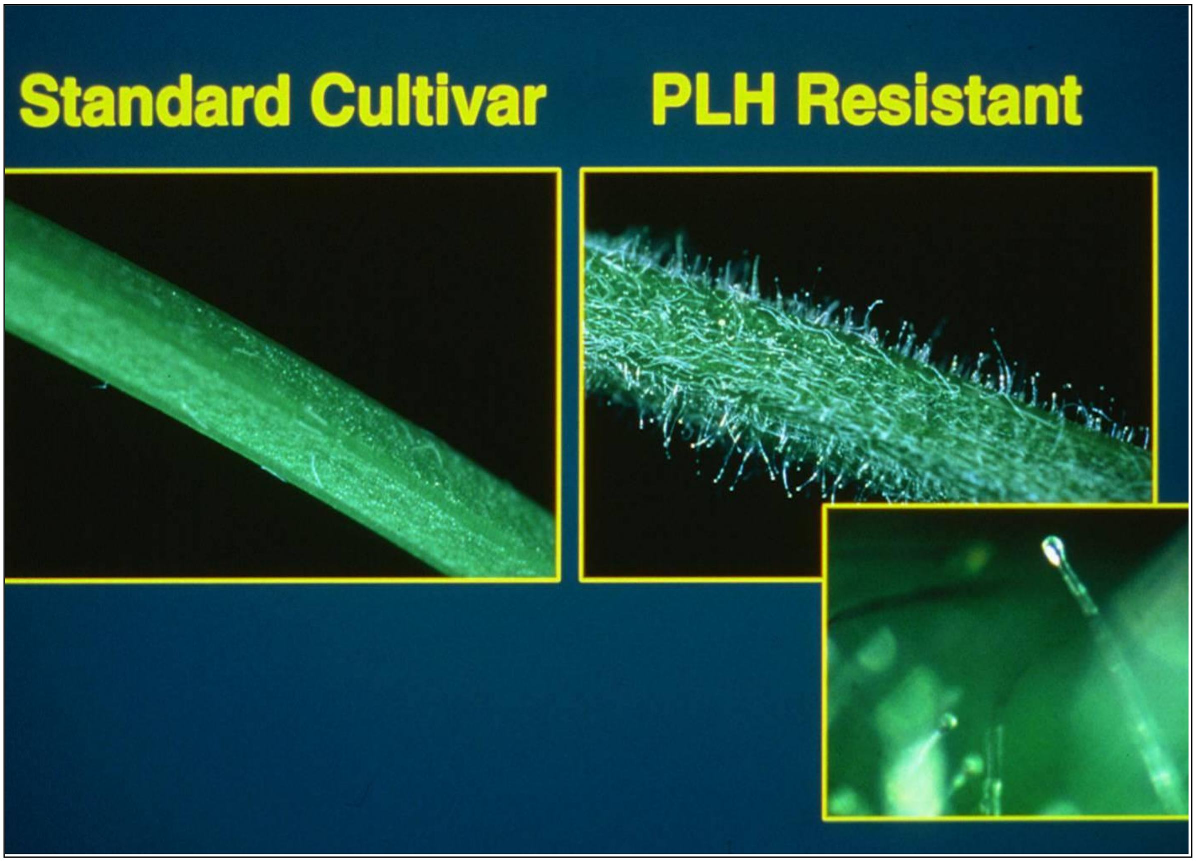


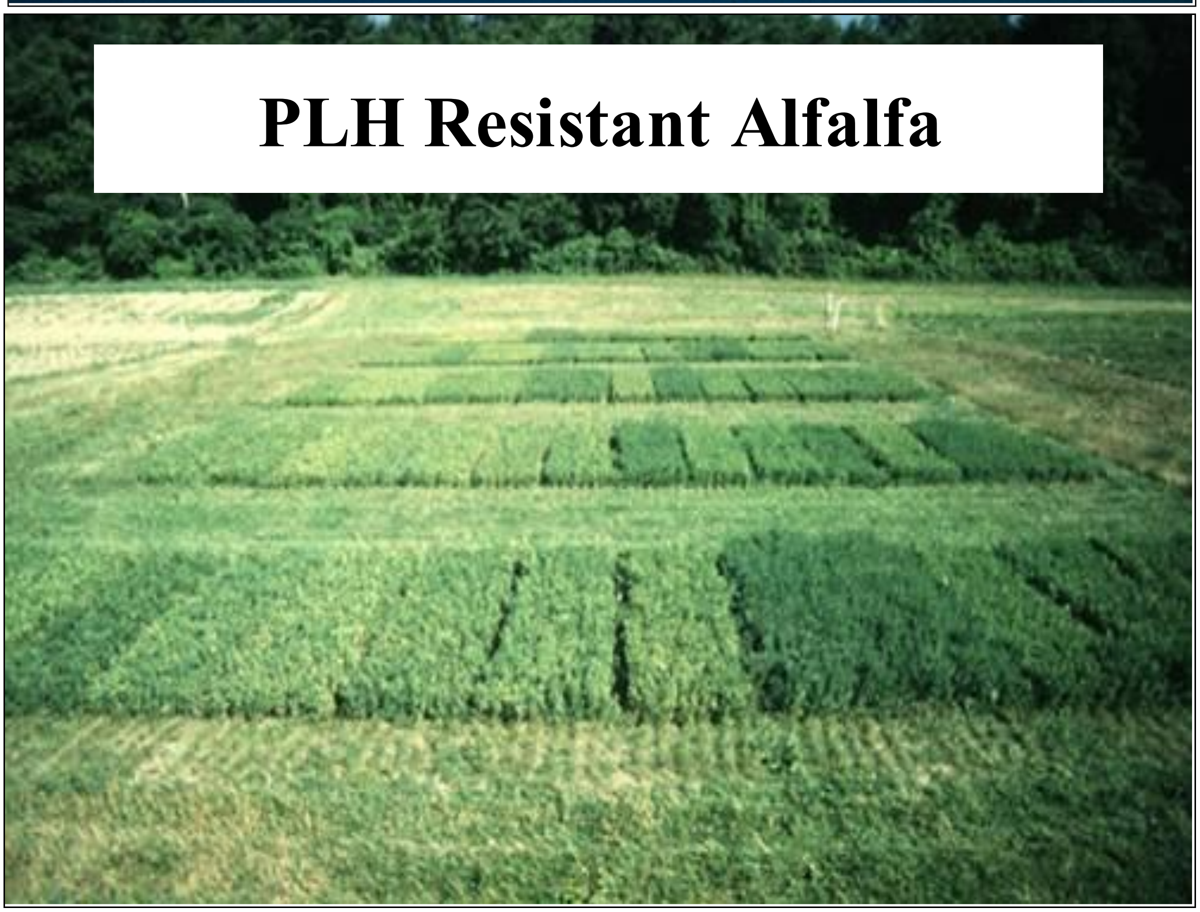


Impact of Environment on Population Dynamics:
With insects being cold blooded, temperature drives the speed of all body functions. A warmer growing season will shorten the duration of each life cycle and a greater number of generations will occur during the growing season. A cooler growing season will lengthen the duration of each life cycle and reduce the number of generations during the growing season.

Impact of Environment on Crop Damage:
Water stress conditions increase the impact of potato leafhopper damage on the yield of alfalfa. Increased transpiration and decreased photosynthesis from potato leafhopper feeding magnifies the impact of water stress on the plant and decreases the yield to a lower level than would be expected with the water stress alone.

Management:
With the current effective array of PLH resistant alfalfa varieties, all new alfalfa stands should be planted to one of the new resistant varieties, regardless if the planting is clear seeded alfalfa or an alfalfa-grass mixture. With the yield impact of potato leafhopper on susceptible alfalfa, the cost of scouting and the cost of insecticide treatment, the planting of susceptible variety makes no business or pest management sense.


Standard Cultivar
PLH Resistant


PLH Resistant Alfalfa

PLH resistance in alfalfa is due to the presence of glandular hairs on the stem and leaves. These hairs inhibit feeding and the laying of eggs in the stems of the plant. The resistance is most effective on the small leafhopper nymphs.

Effective management of PLH in susceptible alfalfa stands requires weekly scouting with a sweep net and the use of the treatment guidelines listed below and in the current version of the Cornell Guidelines for Field Crop Production. When properly applied, insecticides are very effective in the control of PLH.

Potato Leafhopper Scouting

Stem length	leafhopper/sweep
Less than 3 inches	0.2
3 to 7 inches	0.5
8-10 inches	1.0
11-14 inches	2.0
15 inches or taller	if PLH exceed 2.0 per sweep then harvest the field.

27. Be able to discuss how ecological factors such as temperature and moisture influences insect population growth and decline.

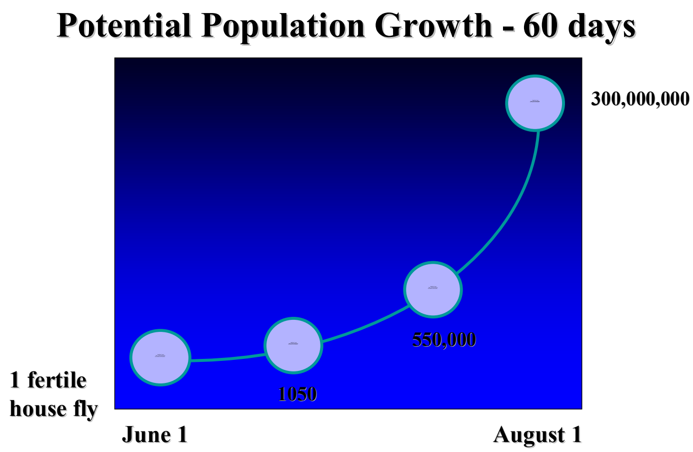
All arthropods are cold blooded and their rate of development is dependent on the surrounding temperatures. Arthropods develop faster as the temperature increases until the temperature becomes too hot for development. Generally, insect development is very slow at temperatures below 50 degrees F and insect development is inhibited when temperatures rise above 90-95 degrees F. An example of the influence on insect development is shown in the figure below.

Impact of Temperature on House Fly Development Rate

Constant Temp.	Hours to Hatch	Days to Pupation	Days to adult	Total Days
68	23	8 - 10	10 - 11	18 - 21
77	14	7 - 8	7 - 9	14 - 17
86	10	5 - 6	4 - 5	9 - 11
95	8	3 - 4	3 - 4	6 - 8

NOTE: Actual fly development varies with normal daily temperature fluctuations
House fly females can lay 4–6 batches of 100–150 eggs over their lifetime.

Insects also have a very large reproductive potential. Usually only a very small percent of the population survive to continue the next generation, but each species usually has a large reproductive potential if the forces of mortality are reduced. When an insect is introduced into a new area without its wide array of natural enemies, the reproductive potential is often released, allowing the invasive insect to become a widespread pest.



Control – Chemical

28. Know the advantages and disadvantages of using pesticides to control arthropod crop pests.

The use of chemical pesticides has long been viewed as the "line of first attack" when the use of pesticides should be viewed as a "strategy of last defense". The past widespread use of pesticides has created as many problems as it has solved. The development of insecticide resistance in insects, herbicide resistance in some weed species and fungicide resistance in an array of plant disease pathogens was predicted by scientists, ignored by the agribusiness industry and has created a number of difficult pest management problems. These situations have led to the development of "resistance management strategies".

Pesticides: Widespread use of insecticides since the 1940's has promoted the development of insecticide resistance in numerous insect species. For a time, the insecticide industry could develop new insecticides as fast as insecticide resistance developed and the issue of resistance management was ignored. With the slowing of insecticide development in the late 1980's, the issue of preserving the various insecticides by managing the exposure of the target insects to the insecticide and reducing the development of insecticide resistance became a key issue. Currently, the use of insecticides only when economic losses are expected and the rotation of different insecticide classes reduces the selection pressure on the insect population to develop insecticide resistance. An additional strategy which helps to prevent the rapid development of insecticide resistance is the deployment of refuges as described in PO #30.

29. Recognize the advantages and disadvantages of target specificity of pesticides used to control arthropod crop pests.

See 29

30. Understand the concepts of resistance management as it pertains to pesticides and genetically modified crops with plant incorporated protectants (PIPs) incorporated into their genome.

Resistance Management: Resistance management is the adoption of agricultural practices which delay, reduce or prevent the development of resistance to a specific pest management strategy. Initially, the genetics for resistance in a population is extremely rare and resistance only becomes a problem when the selection pressure on the population is intense enough that only the resistant individuals survive, interbreed and concentrate the genes for resistance in the population. An effective resistance management program utilizes a wide array of pest management practices which allows enough susceptible individuals to survive to interbreed with the resistant individuals to prevent the concentration of the genetic resistance in the majority of the population.

GMO crops: Many GMO crops have an insect active toxin incorporated into the plant genome. The presence of this toxin in plant tissue has a significantly more potent genetic selection pressure on the insect to develop resistance than the use of a topically applied or systemic insecticide. The plant based toxin is present in the plant at all time where the external insecticide concentration degrades with time, allowing some insects to reduce exposure and survive without mechanisms of genetic resistance. Currently, the EPA requires the planting of GMO-toxin free refuges in coordination with the planting of the insect active GMO crops. For example, the planting of GMO-Rootworm resistant corn varieties requires a 20% refuge plant within the field or immediately adjacent to the field with a corn variety of the same maturity rating where the plant incorporated toxin is absent in the plant. This allows rootworm larvae to survive, emerge as adults and mate with any potential resistant individuals that have successfully survived exposure to the plant based toxin.

Control – Cultural

31. Know examples of and understand the advantages and limitations of cultural controls for arthropod crop pests.

A. Resistant varieties
B. Planting date adjustment
C. Crop Rotation
D. Tillage
E. Harvest date adjustment
F. Sanitation

Cultural control is the generalized term for the use of agricultural practices to reduce the pest pressure on the crop. These tactics include 1) Resistant Varieties, 2) Planting Date Adjustment, 3) Crop Rotation, 4) Tillage Practices, 5) Harvest Date Adjustment, and 6) Sanitation.

- **Resistant Varieties**: Most disease resistance in field crops is incorporated into the varieties through conventional breeding techniques. Selection of the best adapted varieties to a local set of pest pressures is not only a good pest management practice but good agribusiness practice. Examples of disease resistance in corn are Northern Corn Leaf Blight and stalk resistance. An example of insect resistance is the new array of Potato Leafhopper resistant alfalfa which has become available in the past decade.

- **Plant Date Adjustment:** This tactic involves the adjustment of the planting date to minimize pest attack. One classical example is the delay of winter wheat plant date in the fall until the threat of Hessian Fly attack is minimized. In organic production systems, the plant date of corn and soybeans can be adjusted to minimize the attack of seed corn maggot in the spring.

- **Crop Rotation:** Crop rotation is a good agronomic practice which has benefits beyond pest management. In the scope of pest management, systems with continual single crop production build up pest pressure over time. For example, 1st year corn in NY never suffers economic damage from corn rootworm. In contrast, 3rd and 4th year continuous corn builds up an 85-100% probability of economically damaging levels of rootworm larval populations. Similar examples can be cited from the plant disease world. A planned rotation can reduce the pest problems in most crops.

- **Tillage Practices:** A couple of tillage practices which reduce pest pressure include the use of cultivation to reduce weed pressure and the shredding of corn stalks in corn grain production to reduce the overwintering population of European Corn Borer.

- **Harvest Date Adjustment:** The adjustment of harvest can be an effective tool to reduce pest pressure. For example, in alfalfa production, the accelerated harvest of first cutting alfalfa during time of alfalfa weevil feeding can prevent the economic losses from the insect feeding and prevent the cost of an insecticide treatment. Timely harvest, drying and storage can prevent the buildup of fungi molds and associated mycotoxins in grain corn.

- **Sanitation:** Many stored grain insect infestations can be directly linked to the lack of sanitation around the grain storage facility. The simple practice of completely cleaning the grain bin of leftover grain (with associated insects) before the bin is refilled with a new load of grain eliminates many of the stored grain insect problems. In addition, the use of screening on all grain bin openings prevents the insects from entering the facility after the bin is refilled.

Control – Biological

32. Recognize the three major classes of beneficial organisms and know at least two examples of each (parasites, predators and pathogens).

See 33

33. For each example, be able to discuss its importance in pest population regulation. Examples include:

A. Spiders
B. Parasitic wasps
C. Parasitic flies
D. Predaceous insects
E. Predaceous mites
F. Entomopathogenic nematodes
G. Entomopathogenic fungi

All insects within their native homes are held in check with their own array of biological control organisms. These organisms include diseases, parasites and predators. In addition, adverse weather conditions also have a negative impact on insect populations. Insects (and other arthropods) become economic pests when conditions change which negatively impact the biological control organisms and allow the populations of the insect pest to increase to economically damaging levels. These changes can include the introduction of the insect to a new region without the introduction of the natural enemies/diseases or a change in the cropping system which inhibits the biological control activities of the natural enemies and encourages the population buildup of the crop pest. A large number of the current economically important crop pests in field crops are introduced insects into North America from other parts of the world. A couple of examples are European Corn Borer, Alfalfa Weevil, and Cereal Leaf Beetle. Alfalfa weevil and Cereal leaf beetle are generally not considered a widespread economic pest because of successful efforts to establish the biological control organisms from their native homeland which held them in check throughout their native range. Similar efforts for European Corn Borer have not been successful.

In contrast, Western and Northern Corn Rootworm are native to the US and have shifted from their native plants onto cultivated corn. The change of life style and habitat has released these insects from their natural enemies and the enhanced food source (cultivated corn) has allowed the insect to rise closer to their reproductive potential. As a result, corn rootworm is a very significant agricultural pest.

Types of Biological Control Organisms: Biological control organism fall into three different categories. There are insect diseases (viral, fungal, bacterial), internal parasites (parasitoids) and external predators.

- **Insect diseases** (Insect pathology): Each insect species has an array of disease which keep the species in check within its native habitat. When an insect species in introduced into a new environment (usually through human assisted movement), the array of diseases are not usually moved with the insect and the insect population explodes in the new relatively disease free environment. The reintroduction of effective disease organisms into the new area and invasive population has been very effective in controlling invasive insects which become economically important in the new outbreak area. Examples of effective biological control with the use of insect disease organisms are Alfalfa Weevil and Gypsy Moth. Insect attacking nematodes (entomopathogenic) are also considered in the area of insect pathology. Entomopathogenic nematodes are most effective on soil insects.

- **Parasitoids** (internal parasites): Whole groups of insects have adapted their lifestyles as internal parasites of other insect species. Insect parasitoids fall into two groups. The first group are parasitic wasps and the second group are parasitic flies. In both cases, eggs are either laid internally or externally on the insect host. The parasite egg hatches and feeds internally within the host insect. In the process of feeding, the host is killed. After development is completed, the parasitic insect pupates to an adult and emerges from the host insect cadaver. The newly emerged adult then searches for other suitable hosts in which to lay eggs (oviposit). The effectiveness of parasitoids as a biological control agent is determined by the adaptation of the parasitoid species to the new environment in which they are released and the matching of the parasitoid searching behavior to the new environment to which the host insect has adapted to. Examples of effective parasitoid based biological control are Alfalfa Blotch Leafminer, Cereal Leaf Beetle and Alfalfa Weevil (in some years).

- **Predators:** There is a wide array of insect and mite species in numerous orders which have adapted to the role of insect predators. Insect predators search for, attack and consume other insects externally (as contrasted to internal parasitoids). Commonly recognized predators are the Lady-Bird beetle, Lacewings, Big-eyed Bug, and Damsel Bug. In addition, ground beetles, spiders and predaceous mites are also effective predators. Generally, predators are most effective when host insects are in high numbers. Examples of insects controlled by predators are aphids and plant feeding mites.

Competency Area 5: Pesticide Formulations and Labels

34. Recognize the distinction between the federal and state pesticide regulations, and that state regulations can be more restrictive than federal regulations. Be able to explain what to do if state laws are stricter than label directions.

Federal law gives the states the option of being stricter than EPA. A state may restrict products, or remove products from sale and use within its borders. They may also choose to modify labels. States may also decide to interpret label statements to give them a more strict meaning, such as New York interprets the phrase “For Professional Use Only” as meaning this product is a “Restricted Use” product and cannot to be sold to uncertified people. The bottom line is: **the applicator must follow** the more stringent state regulation.

35. Be able to explain the difference between a pesticide label and labeling.

The label is the information printed on or attached to the container of a pesticide. It has information about a pesticide’s characteristics, and proper use. But you also need to know that there are other brochures and flyers that have information about the pesticide product. These additional pieces of information are called “Labeling.” Labeling is all the information that you receive from the manufacturer about the product. It includes the label on the product container plus any supplemental information including the materials safety data sheet (MSDS), brochures, leaflets, and information handed out by your dealer or a recognized authority such as a University. Labeling is just as important to you, the user of the pesticide, as the label.

36. Identify and locate the kinds of information found on a pesticide label.

- Brand, Trade, or Product Names.
  Each manufacturer has a brand name for their product. Different manufacturers may use different brand names for the same pesticide active ingredient. The brand name shows up plainly on the front panel of the label.

- Classification.
  Every use of every pesticide will be classified by the U.S. Environmental Protection Agency as either "general" or "restricted." Every pesticide product which has been restricted must carry this statement in a prominent place at the top of the front panel of the pesticide label: "RESTRICTED USE PESTICIDE. For retail sale and use only by certified applicators or persons under their direct supervision and only for those uses covered by the certified applicator's certification." Your state lead agency has the authority to deem a product as restricted use. When a product has been restricted by a state, the "restricted use" statement will not appear on the label. Contact your state lead agency for the list of state restricted use products.

Ingredient Statement. Each pesticide label must list what is in the product. The list is written so that you can see quickly what the active ingredients are and the amount (in percentage) of each ingredient listed.

- Chemical Name.

The chemical name is a complex name, which identifies the chemical components and structure of the pesticide. This name is almost always listed in the ingredient statement on the label. For example, the chemical name of Sevin 50% WP is 1-naphthyl methyl carbamate.

- Common Name.
  Because pesticides have complex chemical names, many are given a shorter "common" name. Only common names which are officially accepted by the U.S. Environmental Protection Agency may be used in the ingredient statement on the label.

- Type of Pesticide.
  The type of pesticide usually is listed on the front panel of the pesticide label. This short statement usually indicates the kind of pests that the product will control.
  Examples:
  - Insecticide for control of certain insects on fruits, nuts, and ornamentals.
  - Soil fungicide.
  - Herbicide for the control of trees, brush, and weeds.
  - Algaecide

- Name and Address of Manufacturer.
  The law requires the maker or distributor of a product to put the name and address of the company on the label.

- Registration and Establishment Numbers.
  These numbers are needed by the pesticide applicator in case of accidental poisoning, claims of misuse, faulty product, or liability claims.

- Signal Words and Symbols.
  Almost every label contains a signal word that will give you a clue to how dangerous the product is to humans. Knowing the product's hazard helps you to choose the proper precautionary measures for yourself, your workers, and other people (or animals) who may be exposed. The signal word must appear in large letters on the front panel of the pesticide label. It usually is next to the statement, "Keep Out of Reach of Children" which must appear on every pesticide label.

  DANGER Any product, which is highly toxic orally, dermally, through inhalation, or causes severe eye or skin burning, will be labeled DANGER. All pesticides which are highly toxic orally, dermally, or through inhalation will also carry the word POISON printed in red and the skull and crossbones symbol.

  If a pesticide receives a highly toxic rating because of the possibility for corrosive damage to the skin or eyes, the signal word DANGER will be on the label without the word POISON.

  WARNING Any product which is moderately toxic orally, dermally, or through inhalation or causes moderate eye and skin irritation, will be labeled WARNING.

  CAUTION Any product which is slightly toxic to relatively non-toxic orally, dermally, or through inhalation or causes slight eye and skin irritation, will be labeled CAUTION.

Precautionary Statements.
All pesticide labels contain additional statements to help you decide the proper precautions to take to protect yourself, your helpers, and other persons (or domestic animals) which may be exposed.

- Hazards to Wildlife.
  The label may indicate that the product causes undesirable effects in the environment. In this case, the precautionary statement may tell you what to avoid doing. Some labels indicate toxicity to bees, birds, fish and crustaceans. Labeling may indicate limitations imposed to protect endangered species. These limitations may include reduced rates, restrictions on types of application, or a ban on the pesticide's use within the species range. The label may also tell you where additional information can be obtained.

- Protective Clothing and Equipment Statements.
  Pesticide labels vary in the type of protective equipment statement they contain. You should follow all advice on protective clothing or equipment, which appears on the label.

- Environmental Hazards.
  Pesticides may be harmful to the environment. Some products are classified RESTRICTED USE because of environmental hazards alone. Label warnings may include groundwater advisories and protection information. Look for special warning statements on the label concerning hazards to the environment.

- Special Toxicity Statements.
  If a particular pesticide is especially hazardous to wildlife, it will be stated on the label. E.g.:
  - This product is highly toxic to bees.
  - This product is toxic to fish.
  - This product is toxic to birds and other wildlife.

  These statements alert you to the special hazards that the use of the product may pose. They should help you choose the safest product for a particular job and remind you to take extra precautions.

  - General Environmental Statements.

  These statements appear on nearly every pesticide label. They are reminders of common sense actions to follow to avoid contaminating the environment. The absence of any or all of these statements DOES NOT indicate that you do not have to take adequate precautions. Sometimes these statements will follow a "specific toxicity statement" and provide practical steps to avoid harm to wildlife.

  Examples of general environmental statements include:
  - Do not apply when runoff is likely to occur.
  - Do not apply when weather conditions favor drift from treated areas.
  - Do not contaminate water when cleaning equipment or disposing of wastes.
  - Keep out of any body of water.
  - Do not allow drift on desirable plants or trees.
  - Do not apply when bees are likely to be in the area.
  - Do not apply where the water table is close to the surface.

- Physical or Chemical Hazards.

This section of the label will tell you of any special fire, explosion, or chemical hazards the product may pose. For example:

- Flammable; Do not use, pour, spill, or store near heat or an open flame. Do not cut or weld container.
- Corrosive; Store only in a corrosion-resistant tank.

- Storage and Disposal.
  All pesticide labels contain general instructions for the appropriate storage and disposal of the pesticide and its container. State and local laws vary considerably, so specific instructions usually are not included.

- Directions for Use.
  Correct application of a pesticide product is accomplished by following the use instructions found on the label. The use instructions will tell you:
  - The pests which the manufacturer claims the product will control.
  - The crop, animal, or site the product is intended to protect.
  - In what form the product should be applied.
  - The proper equipment to be used.
  - How much to use.
  - Mixing directions.
  - Compatibility with other often-used products.
  - Phytotoxicity and other possible injury or straining problems.
  - Where the material should be applied.
  - When it should be applied.
  - Labels for agricultural pesticides often list the least number of days which must pass between the last pesticide application and crop harvest, slaughter, or grazing livestock. These are intervals set by EPA to allow time for the pesticide to break down in the environment. This prevents illegal residues on food, feed, or animal products and possible poisoning of grazing animals. This information may appear as a chart or it may be listed just after the application.

37. Know the four times when you should read the pertinent parts of a label

The first rule of pesticide application is “Read the Label First!” This is a simple way to remember that reading the label is fundamental to using the pesticide properly. There are four (4) times when you should read the pertinent parts of a label. You will learn to go to the correct part of the label and read and re-read those instructions that you want to review.

1. Before you buy the pesticide,
2. Before you mix the pesticide,
3. Before you apply the pesticide, and
4. Before you store or dispose of the pesticide.

38. Be able to explain the meaning of the phrase “Use Inconsistent with Labeling”.

The source of the label’s legal power is law, specifically the law called FIFRA (The Federal Insecticide Fungicide and Rodenticide Act). FIFFA contains the following statement, which must appear on the pesticide label:

“**It is a violation of federal law to use this product in any manner inconsistent with its labeling.”**

In short, you are forbidden to use a pesticide contrary to the labeling. The label is a "permission document." Any use not indicated on the label is prohibited. Likewise, consultants or sales persons cannot legally recommend a pesticide be used contrary to its' labeling.

Competency Area 6: Management of Pesticide Resistance

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39. Define pesticide resistance, and be able to describe how it develops in a pest population. Know examples of resistant field crop pests in the Northeast.

See "About Pesticides: Resistance Management" by the Government of British Columbia (http://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/animals-and-crops/plant-health/pesticides-agriculture/using-pesticides/resistance-management) for a general introduction on this topic. See also "http://www.clemson.edu/weeds/Herbicide_Resistance.pdf". See 21-A for details about herbicide-resistant weeds and herbicide resistance management.

Competency Area 7: Using Pesticides in an Environmentally Sound Manner

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Pesticide Movement in Soil and Water

40. Recognize how movement of a pesticide in soil or into water may be affected by:

- **A. Soil texture**
- **B. Erosion**
- **C. Pesticide degradation**
- **D. Pesticide persistance**
- **E. Degradation processes**
- **F. Leaching**
- **G. Precipitation runoff**
- **H. Pesticide solubility**
- **I. Pesticide adsorption**
- **J. Source of entry into the environment**

See: http://psep.cce.cornell.edu/facts-slides-self/facts/pestmgt-water-qual-90.aspx for a copy of "Pesticide Management for Water Quality; Principles and Practices. Van Es, H.M, and N.M. Trautmann. October 1990. This bulletin describes, among others, pesticide movement in soil and water.

41. Understand soil/pesticide interactions and their influence on pesticide selection, pesticide use, and water quality protection. Be aware of pesticide runoff/leaching potential predicting tools such as Win-PST 3 and be able to recommend mitigation to improve or minimize the negative effects on the environment.

See: http://psep.cce.cornell.edu/facts-slides-self/facts/pestmgt-water-qual-90.aspx for a copy of "Pesticide Management for Water Quality; Principles and Practices. Van Es, H.M, and N.M. Trautmann.

October 1990. This bulletin contains information on soil/pesticide interactions and their influence on pesticide selection, use, and water quality protection. The USDA-NRCS National Water and Climate Center developed and supports the Windows Pesticide Screening Tool (WIN-PST). WIN-PST is a pesticide environmental risk screening tool that NRCS field office conservationists, extension agents, crop consultants, pesticide dealers and producers can use to evaluate the potential for pesticides to move with water and eroded soil/organic matter and affect non-target organisms. For more information on Win-PST 3, see http://go.usa.gov/Kok.

42. Recognize how the following impact proper pesticide use in regard to water quality protection: soil characteristics, ground cover, proximity to water sources (surface water, groundwater, wells, etc.).

See: **http://pmep.cce.cornell.edu/facts-slides-self/facts/pestmgt-water-qual-90.html** for a copy of "Pesticide Management for Water Quality; Principles and Practices. Van Es, H.M, and N.M. Trautmann. October 1990.

Government Regulations

43. Recognize the general provisions of state pesticide regulation laws.

The New York State Department of Environmental Conservation (DEC) is the agency responsible for administration and enforcement of New York State pesticide laws. Article 33 of the Environmental Conservation Law provides the general framework for the distribution, sale, use and transportation of pesticides in New York. In addition, Title 3 of Article 15 requires a permit for aquatic pesticide use in certain circumstances. Title 29 of Article 71 provides the enforcement provisions for Article 33. New York State Pesticide regulations are found in 6 New York Code of Rules and Regulations (6 NYCRR) Parts 320-329. Part 325 contains regulations on the application of pesticides, including commercial and private pesticide applicator certification requirements and pesticide business registration. Part 326 contains pesticide product restrictions, including restricted use pesticides, banned pesticides, pesticide-specific limitations, and commercial permit requirements. More information about New York state pesticide regulations can be found on the DEC website at: **http://www.dec.ny.gov/chemical/298.html.** For New England states, check the local governing bodies.

44. Recognize the general provisions of recent EPA regulations such as the Clean Water Act and Worker Protection Standards.

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) is the primary law that regulates how pesticides are produced, transported, sold, used, and disposed of. FIFRA also establishes the process for the registration and re-registration of pesticide products and directs the certification of pesticide applicators. All states, tribes, and territories must comply with FIFRA regulations and may establish additional pesticide regulations as long as they are not less stringent than the FIFRA requirements. Other important pesticide-related laws include the Federal Food, Drug, and Act (FFDCA), the Worker Protection Standard (WPS), the Endangered Species Act (ESA) and the Clean Water Act. The FFDCA regulates the tolerances (i.e., the maximum amounts of pesticide residue) that may remain in human food and animal feed. Several government agencies, including the Food and Drug Administration (FDA) and the U.S. Department of Agriculture (USDA), test food and feed products to ensure they do not exceed legal tolerances. To set tolerance levels, the Environmental Protection Agency (EPA) has established a complex process that involves the review of many scientific studies. This process is necessary for ensuring the safety of food and feed products in the United States.

The WPS is a regulation aimed at reducing the risk of pesticide exposure to agricultural workers and pesticide handlers. Under this regulation, owners and operators of agricultural establishments or commercial businesses must comply with a list of requirements for establishing a safe work environment for employees. Pesticide safety training for all agricultural workers and pesticide handlers is one of the WPS requirements.

The ESA protects endangered or threatened species from harm, including any harm they might encounter from pesticides. Under the Endangered Species Protection Program, pesticide products that might adversely affect an endangered species must carry a statement instructing applicators to consult a county bulletin to determine if they must take any special measures to protect an endangered species when using the product. It is the applicator's responsibility to obtain the bulletin and comply with the special precautions.

The Clean Water Act (CWA) is the cornerstone of surface water quality protection in the United States. The statute uses a variety of regulatory and non-regulatory tools to reduce direct pollutant discharges into waterways, finance municipal wastewater treatment facilities, and manage polluted runoff. The CWA made it unlawful to discharge any pollutant from a point source into navigable waters, unless a permit was obtained. These tools are employed to achieve the broader goal of restoring and maintaining the chemical, physical, and biological integrity of the nation's waters so that they can support "the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water."

Competency Area 8: Protecting Humans from Pesticide Exposure

Keeping Pesticides on Target

45. Be familiar with spray drift and problems drift can cause for applicators and others.

Drift occurs when air currents cause pesticide to be deposited outside a target application site. It may occur as solid or liquid particles at the time of application or as vapors during or after application. Any pesticide that is carried out of the target area by wind or any air current may damage non-target plants, contaminate surface waters, harm wild and domesticated animals, or harm people. Herbicide drift tends to be the most noticeable because of its visible effect on plants. "Invisible" effects can also be bad. For example, any pesticide drift might produce illegal residues on a neighbor's crop; even legal residues could be a problem for an organic producer. Because drift can harm, civil, criminal, or administrative penalties (such as fines) may result. Note that both the applicator and the person (if any) who directs the applicator to use the pesticide can be held responsible for drift. Legal problems may not be the only costs associated with drift. If drift does cause harm, the injured party may choose to sue. Your insurance company may raise your deductible and premiums. Finally, there is the intangible cost of strained relations with neighbors and your clients if drift harms them or their property.

46. Know the factors that affect particle drift and why they affect drift:

A. Droplet size
B. Wind speed
C. Nozzle distance from target
D. Temperature and humidity

The obvious intent of spraying a pesticide is to deposit droplets on the crop or soil surface. However, a lot can happen to a droplet in the distance between a nozzle and the crop or soil.

(a) **Droplet size.** Smaller droplets fall more slowly, evaporate more quickly, and are more easily moved by wind. Therefore, they will be carried farther by wind before they are deposited.
(b) **Wind speed.** A stronger wind means droplets will be carried farther before they are deposited. This is true for any size droplet, though the effect is still greater on smaller droplets.
(c) **Nozzle height.** The higher a boom or nozzle is set above the target surface, the farther a droplet must travel before being deposited. This means the droplet will be in the air longer and subject to evaporation and wind longer.
(d) **Temperature increases and humidity decreases.** As the air gets warmer and/or drier, the water in the spray droplets evaporates faster. This makes droplets effectively smaller, making them more prone to drift.

Spray droplet size is the most important factor affecting the potential for particle drift. Wind speed is also very important. However, increasing droplet size can greatly reduce the wind's effect.

The active ingredient is not a significant factor in particle drift. The effects of formulation and physical properties of the spray mix are also much smaller than those of droplet size, wind speed, and nozzle height.

47. Know factors that affect spray droplet size:

A. Spray pressure
B. Nozzle size
C. Spray rate (gallons per acre)
D. Drift control agents (foams, invert emulsions, spray additive stabilizers, etc.)

Droplet size is the most important factor affecting the potential for particle drift and that smaller droplets drift farther than large droplets. Spray droplets less than 150 microns in diameter are more prone to drift and droplets less than 50 microns being highly susceptible to drift. (For reference, 50 microns is about the diameter of a human hair.)

There will always be a range of droplet sizes in any spray pattern. You cannot eliminate small droplets but you can reduce the proportion of them in the spray once you know what affects droplet size. Increased spray pressure increases the number of small droplets produced. Keep the pressure as low as possible within the range for the nozzle and product you are using.

Nozzles with larger openings or narrower spray angles will produce fewer fine droplets. Using wider spray angles may allow you to bring the nozzles closer to the target surface. Doing so more than compensates for the finer spray. Some nozzles (such as a turbo flat-fan or air induction nozzle) are specifically designed to produce fewer fine droplets.

Higher spray rates (gallons of spray mix per acre) let you use nozzles with larger openings. Thus, if you need to increase spray rates, use larger nozzles rather than increasing spray pressure.

Drift reduction adjuvants such as foams, invert emulsions, or stabilizers reduce the number of small spray droplets but they will also reduce coverage of the plant surface. Be sure to use adjuvants according to the directions on the pesticide label to avoid problems. A pesticide label may require the use of drift-reduction agents under certain conditions, such as low application rates.

Human Toxicity

48. List pesticide modes of entry into the human system.

There are three specific ways in which pesticides may enter your body. Pesticides may enter the body through the skin, lungs or mouth.

Dermal Route

Wet, dry, or gaseous forms of pesticides can be absorbed through the skin. This may occur if pesticides are allowed to get on the skin while mixing or applying, or if pesticide-contaminated clothing is not removed promptly and properly cleaned before being worn again. Oil or paste forms allow greater absorption through the skin than water-based pesticides. Some pesticides do not pass through the skin very readily. Others are quickly absorbed through the skin and can be as dangerous as if they were swallowed. Skin varies in its capacity to act as a barrier to pesticide absorption. The eyes, eardrums, scalp and groin areas absorb pesticides more quickly than other areas on the body. Damaged or open skin can be penetrated by a pesticide much more readily than healthy, intact skin. Once they are absorbed through skin, pesticides enter the blood stream and are carried throughout the body.

Inhalation Route

Whether as dusts, spray mist, or fumes, pesticides can be drawn into your lungs as you breathe. Inhalation of pesticides can occur during the mixing of wettable powders, dusts, or granules. Poisoning can also occur while fumigating or spraying without a self contained breathing apparatus or a proper respirator in enclosed or poorly ventilated areas such as greenhouses, apartments, or grain bins. The number of particles needed to poison by inhalation depends upon the concentration of the chemical in the particles. Even inhalation of dilute pesticides can result in poisoning. Once they are absorbed through the surfaces of the lungs, chemicals enter the blood stream and are distributed to the rest of the body.

Oral Route

Pesticides can enter the body through the mouth (also called ingestion). This can occur when hands are not properly washed before eating or smoking. They may be swallowed by mistake, if they are improperly stored in food containers. Ingested materials can be absorbed anywhere along the gastrointestinal tract; the major absorption site is the small intestine. Once absorbed, they eventually enter the blood stream by one of several means, and circulate throughout the body.

49. Distinguish between chronic and acute poisoning effects.

Acute exposure refers to a one-time contact with a pesticide. When experimental animals are exposed to a pesticide to study its acute toxicity, acute exposure is defined as contact for 24 hours or less. Acute

effects can be readily detected and more easily studied than chronic effects. Immediate toxic effects are more likely to be produced by those pesticides that are rapidly absorbed.
Chronic exposure refers to a repeated contact with a pesticide. The study of chronic toxicity is accomplished by repeatedly exposing test animals for more than three months. In addition to producing long-term low-level effects, chronic exposure to pesticides may result in immediate, "acute" effects after each exposure. In other words, frequent exposure to a chemical can produce acute and chronic symptoms. The potential for a chronic effect is related to the level and frequency of exposure received.

50. Recognize general symptoms of acute pesticide poisoning.

Mild Poisoning or Early Symptoms of Acute Poisoning headache, fatigue, weakness, dizziness, restlessness, nervousness, perspiration, nausea, diarrhea, loss of appetite, loss of weight, thirst, moodiness, soreness in joints, skin irritation, eye irritation, irritation of the nose and throat.

Moderate Poisoning or Early Symptoms of Acute Poisoning nausea, diarrhea, excessive saliva, stomach cramps, excessive perspiration, trembling, no muscle coordination, muscle twitches, extreme weakness, mental confusion, blurred vision, difficulty in breathing, cough, rapid pulse, flushed or yellow skin, weeping.

Severe or Acute Poisoning fever, intense thirst, increased rate of breathing, vomiting, uncontrollable muscle twitches, pinpoint pupils, convulsions, inability to breathe, unconsciousness.

51. List possible chronic effects of pesticide poisoning.

Chronic poisoning is the poisoning which occurs as a result of repeated, small, non-lethal doses over a long period of time. Many symptoms may appear, such as nervousness, slowed reflexes, irritability, or a general decline in health. Some test animals are unable to reproduce normally after repeated exposure to pesticides.

52. Recognize general procedures to follow if pesticide gets on skin, in eyes, in mouth or stomach, or if inhaled.

Poison on the Skin

- The faster the poison is washed off the patient, the less injury that will result.
- Drench skin and clothing with water (shower, hose, faucet, pond).
- Remove clothing.
- Cleanse skin and hair thoroughly with soap and water. Detergents and commercial cleansers are better than soap.
- Dry and wrap in a blanket.
- **WARNING:** Do not allow any pesticide to get on you while you are helping the victim.

Poison in the Eye

- It is most important to wash the eye out quickly but as gently as possible.
- Hold eyelids open and wash eye with a gentle stream of clean running water.
- Continue washing for fifteen minutes or more. It is important to use a large volume of water. If possible, at least five gallons should be used to flush the eye properly.
- Do not use chemicals or drugs in wash water. They may increase the extent of the injury.

- Cover the eye with a clean piece of cloth and seek medical attention immediately.

Inhaled Poisons (dusts, vapors, gases)

- If victim is in an enclosed space, do not go in after him unless you are wearing an air-supplied respirator.
- Carry patient (do not let him walk) to fresh air immediately.
- Open all doors and windows.
- Loosen all tight clothing.
- Apply artificial respiration if breathing has stopped or is irregular.
- Keep victim as quiet as possible.
- If victim is convulsing, watch his breathing and protect them from falling and striking his head. Keep his chin up so his air passage will remain free for breathing.
- Prevent chilling (wrap patient in blankets but don't overheat).
- Do not give the victim alcohol in any form.

Swallowed Poisons When should you make the victim vomit?

The most important choice to make when aiding a person who has swallowed a pesticide, is whether or not to make them vomit. The decision must be made quickly and accurately by a health care professional because the victim's life may depend on it. Get help from a physician or the poison control center. .. **But it is important to know:**

- **Never** induce vomiting if the victim is unconscious or is having convulsions. The victim could choke to death on the vomitus.
- **Never** induce vomiting if the victim has swallowed a corrosive poison.
- **Never** induce vomiting if the person has swallowed petroleum products such as kerosene, gasoline, oil, or lighter fluid. Most pesticides, which come in liquid formulations, are dissolved in petroleum products.

53. Recognize that Material Safety Data Sheets are the best source of information concerning level of toxicity, handling precautions, first aid procedures, and other safety information.

A **material safety data sheet** (**MSDS**) is an information sheet containing the properties of a pesticide. They are an important part of workplace safety, intended to provide workers and emergency personnel with procedures for handling a substance in a safe manner. MSDS will include physical data (melting point, boiling point, flash point, etc.), toxicity, health effects, first aid, reactivity, storage, disposal, protective equipment, and spill handling procedures.

Handling Pesticides Safely

54. Describe protective gear used during mixing and application of pesticides.

Gloves

Always wear unlined, elbow length chemical-resistant gloves when handling all pesticides. The elbow length gloves protect your wrists and prevent pesticides from running down your sleeves into your gloves. Glove materials include nitrile, butyl, neoprene, natural rubber (latex), polyethylene, polyvinylchloride (PVC) and barrier laminates like 4H® and Silver Shield®. Current research indicates that nitrile, butyl, and neoprene offer good protection for both dry and liquid pesticides. Neoprene is not recommended for fumigants. Natural rubber is only effective for dry formulations. Never use leather or cotton gloves. Cotton and leather gloves can be more hazardous than no protection at all because they absorb and hold the pesticide close to your skin for long periods of time. Clean and store gloves for reuse. Replace gloves periodically because most materials will accumulate pesticide residues over time. Nitrile and neoprene gloves can be used for 120 to 160 work hours. Replace PVC and natural rubber gloves after 40 work hours. Slash discarded gloves so that they cannot be used by someone else. Wrap in a plastic bag and put with an empty pesticide container for proper disposal.

Body Covering

Regular work attire of long pants and a long-sleeved shirt, shoes, and socks are acceptable for slightly toxic (category III) and relatively non-toxic (category IV) pesticides. Many applicators prefer work uniforms and cotton coveralls that fit the regular-work-attire description and provide equal protection. Applicators should reserve one set of clothing for pesticide use only. Launder and store separately from all other clothing. To apply moderately toxic (category II) or highly toxic (category I) chemicals, wear a clean, dry protective suit that covers your entire body from wrists to ankles. The sleeves must be long enough to overlap with gloves. Openings, such as pockets, should be kept to a minimum. Protective suits are one- or two-piece garments, such as coveralls. They should be worn over regular work clothes and underwear. Protective suits may be disposable or reusable. They are available in woven, nonwoven, coated and laminated fabrics. The degree of protection increases as one moves from woven to nonwoven to coated and laminated fabrics. Read the manufacturer's label for specific information related to care and intended use. Good quality construction, proper fit, and careful maintenance or disposal are also important. Fabrics can be made more resistant to pesticide penetration by laminating fabric layers and/or by applying chemical coatings. Chemical -resistant protective suits of coated or laminated fabrics are a must if you (or your helper) will be in a mist or spray that would wet your clothing. Coated and laminated fabrics resist water penetration, but not all of these fabrics qualify as chemical resistant. Chemical-resistant suits are recommended when handling highly toxic (category I) pesticides.

Apron

Wear a chemical-resistant apron when repairing or cleaning spray equipment and when mixing or loading. This is a good practice for all pesticides. It is essential for pesticides of category I and II toxicity. Aprons offer excellent protection against spills and splashes of liquid formulations, but they are also useful when handling dry formulations such as wettable powders. Aprons can be easily worn over other protective clothing and are comfortable enough for use in warm climates. Choose an apron that extends from the neck to at least the knees. Some aprons have attached sleeves. Nitrile, butyl, and neoprene offer the best protection. PVC and natural rubber are also available.

Boots

Wear unlined chemical-resistant boots which cover your ankles when handling or applying moderately or highly toxic pesticides. Purchase boots with thick soles. Nitrile and butyl boots appear to give the best protection. Do not use leather boots. If chemical-resistant boots are too hot to wear in warm climates or too difficult to put on, try wearing chemical-resistant overboots with washable shoes (such as canvas sneakers or layered socks.) Remember to put your pant legs outside the boots, otherwise the pesticide can drain into the boot. Wash boots after each use and dry thoroughly inside and out to remove all pesticide residue.

<u>Goggles or Face Shield</u>
Wear shielded safety glasses; a full-face respirator; snug-fitting, non-fogging goggles; or a full-face shield whenever the chemical could possibly contact your eyes. Safety glasses with brow and side shields are acceptable for low exposure situations. Always wear goggles or full-face respirator when you are pouring or mixing concentrates or working in a highly toxic spray or dust. In high exposure situations when both face and eye protection are needed, a face shield can be worn over goggles. Clean them after each use.

<u>Head and Neck Coverings</u>
The hair and skin on your neck and head must be protected too. This is most important in situations where exposure from overhead dusts or sprays is possible, such as in airblast spraying operations or flagging. Chemical-resistant rain hats, wide brimmed hats, and washable hard hats (with no absorbing liner) are good. In cool weather, chemical-resistant parkas with attached hoods are a good choice. If the attached hood is not being used, tuck it inside the neckline so that it will not collect pesticides. Do not use cotton or felt hats; they absorb pesticides.

55. Describe proper cleanup procedures for application equipment and protective gear.

The outside of the PPE, especially gloves, should be washed at rest breaks or every four hours. Replace the PPE after that period of time with clean items or thoroughly wash the outside with soap and water. Replace the PPE after that period of time with clean items or thoroughly wash the outside with soap and water. After each use, wash the face piece with detergent and warm water. Rinse thoroughly and wipe dry with a clean cloth. Store the respirator, filters, and cartridges in a clean, dry place away from pesticides. A tightly closed plastic bag works well for storage. Shower and clean yourself thoroughly from head to toe. Pay particular attention to fingernails and hair where pesticides could remain.

<u>Care of Equipment</u>
Whether equipment is very simple or very complex, it must be properly cared for so it will be both dependable and safe. Cleaning equipment including hoses, nozzles, pumps, tanks and hoppers is very important. Pumps and other equipment that will be stored in below freezing weather should be thoroughly drained, or better yet alcohol or antifreeze should be circulated through the equipment. Nozzles should be removed, cleaned, and stored.

<u>Cleaning Sprayers</u>
Clean the sprayer after each days use. Be sure to wear appropriate protective clothing when cleaning any piece of application equipment. Flush with clean water inside and out to prevent corrosion and accumulation of chemicals. When finished for the season or when changing chemicals, clean the sprayer thoroughly with a cleaning agent. Be careful to avoid contaminating water supplies and avoid injury to plants or animals when washing.

These steps are suggested:
1. Wash off the inside of the tank and partially fill it with water. Flush this water through the nozzles. When the tank is empty repeat these steps so that two complete rinses are done.
2. Take off the nozzle tips and screens. Clean them in a strong detergent solution using a soft brush.
3. Fill the tank a third time, this time adding a cleaning agent. Refer to the table on the following page for information on the type and amount of cleaning agent.

Cleaning Granular and Dust Application Equipment
These devices must also be cleaned following use. Here are some recommended steps:
1. Remove all pesticide from the device. This may require taking it apart to be thorough.
2. Clean the inside of the hopper.
3. Use sand paper or a wire brush to clean rusted parts. Paint the cleaned parts.
4. Coat the inside with oil. Oil or grease the bearings.
5. Thoroughly clean and oil the flow control slides or valves.
6. Excess oil should be wiped off if it will contact the chemical upon the next use.

56. Recognize proper ways to dispose of pesticides and containers.

If you have pesticides that you cannot use or do not want, you must take steps to safely and legally dispose of them. Pesticides, which are still factory-sealed, may be returned to the manufacturer. Check with the company and see if they will take your surplus back. You may be able to apply the excess pesticide mixture to another site where a pest problem exists and that can be treated with the same pesticide. If possible use the rinsewater from your spray tank in a future spray mix of the same pesticide. Be careful with herbicide-contaminated rinsewater on sensitive plants. Caution must also be exercised with reusing rinsewater in mixtures of other pesticides. It is not legal and may cause illegal food or feed crop residues. Never dispose of pesticide contaminated rinsewater in a manner that will contaminate public or private water sources or sewage treatment facilities.

Farmers who need to dispose of a surplus spray mixture or contaminated rinsewater should do so on their own property, only if it is not prohibited on the label and only in labeled sites. If the manufacturer won't take back the concentrates and/or they cannot be used, safe and legal ways to dispose of the surplus must be found. Other certified applicators might be able to use the pesticide leftovers to control a similar pest problem. If containers begin to leak or are damaged, they should be packed in another container that is appropriately labeled. Store your extra pesticides in a locked storage area while you are waiting to dispose of them. They must be kept in their original containers with the label intact.

Empty Pesticide Containers
Empty pesticide containers are not really "empty." They still contain small amounts of pesticide even after they have been rinsed out properly. Never toss them into streams, ponds, fields, or vacant buildings. Be able to account for every pesticide container you used for the job. Never give them to children to play with or allow uninformed persons to have them for any use. Dispose of all your pesticide containers carefully and properly.

57. Describe safe storage of pesticides.

Choosing the Best Site.
Whether you choose a site to build a new storage area or use existing buildings, you need to consider several points. The site should be in an area where flooding is unlikely. It should be downwind and downhill from sensitive areas such as houses, ponds, and play areas. There should be no chance that runoff or drainage from the site could contaminate surface or groundwater. Sites should be selected so that the soil, geologic, and hydrologic characteristics will not lead to contamination of any water systems through runoff or percolation.
Setting Up the Storage Area.

Pesticides should be stored in a cool, dry, airy room or building which is fire proof. Fans are an important feature of any pesticide storage building. A properly installed ventilation system should have a switch outside, so that the fan can be turned on before anyone enters the facility. The storage area should be fenced in or at least able to be locked tightly. Weatherproof warning signs should be hung over every door and window.

58. Recognize procedures to follow when a pesticide spill occurs.

The most hazardous activities involving pesticides are mixing and loading of concentrates. The following procedures are recommended for cleaning up small spills or spills that will not contaminate water. Remember to wear all protective clothing indicated on the pesticide label during the entire cleaning process.

1. Contain the spill. Do everything possible to immediately stop the leak or spill. If the material is a liquid, construct a dam to prevent it from spreading.
2. Isolate the contaminated area. Rope off the area or use chalk to draw a line around it. Keep people at least 30 feet away from the spill.
3. Soak up the spill. Spread an absorbent material such as vermiculite, fine sand, or sawdust over the entire spill.
4. Collect the material for disposal. Sweep or shovel the contaminated absorbent material into a heavy-duty plastic bag.
5. Decontaminate the area. For floors, work a decontamination agent (usually hydrated lime or a high pH detergent) into the spill area with a coarse broom. Add fresh absorbent material to soak up the now contaminated cleaning solution. Sweep or shovel the contaminated material into a heavy-duty plastic bag. Repeat this procedure several times to ensure thorough decontamination. For soils, shovel the top 2 to 3 inches of soil into a heavy-duty plastic bag. Next, cover the area with at least 2 inches of lime. Finally, cover the lime with clean topsoil. Minor spills can sometimes be cleaned up by immediately applying activated charcoal to the contaminated surface.
6. Clean up contaminated vehicles and equipment. Use a mixture of liquid bleach and alkaline detergent to clean metal surfaces. Porous materials and equipment such as brooms, leather gloves, and sponges cannot be decontaminated effectively and, therefore, must be disposed of.
7. Dispose of contaminated materials. Remember that this includes contaminated absorbent materials, soil, and porous equipment. Check with your state regulatory agency for information on how to properly dispose of these materials. Most can be disposed of in a licensed sanitary landfill, but some contaminated materials are considered hazardous waste and require special handling.

For major spills, or spills that may contaminate water, follow the first three steps under the directions for cleaning up minor spills. Then call the CHEMTREC telephone number (800) 424-9300. A qualified person will answer and direct you regarding what procedures to follow and whom to notify. If necessary, the area coordinator will dispatch a pesticide safety team to the site.

Spills may also require notification steps to other authorities. If a state highway is the site of a spill, notify the highway patrol and the state highway department. If food is contaminated, notify state or federal food and drug authorities and city, county, or state health officials. If water is contaminated, notify public health authorities; regional, state, or federal water quality or water pollution authorities; and the state fish and game agency.