Module 5

Integrated Pest Management

Upon completion of Module 5 Integrated Pest Management, you will have a further understanding of:

- *Components of an IPM Program including cultural, mechanical, physical, biological, behavioral and chemical treatments,*
- *Pests and beneficial organism identification,*
- *Recognition of pests and their lifecycles,*
- *Importance of monitoring and how to perform effective monitoring,*
- *Injury and action thresholds, and*
- *How pesticide resistance develops.*

Integrated Pest Management (IPM)

The goal of pest management is to manage pests effectively, economically and safely. Pest management usually involves suppressing pests to an acceptable level. It does not usually involve totally eliminating the pest.

IPM is a decision making process for preventing pest problems and for determining what actions to take when pest problems occur. In IPM programs, all available information and treatment methods are considered in order to manage pest populations effectively, economically and in an environmentally sound manner

IPM has the potential to increase effectiveness, reduce cost and make pest control safer. IPM means "better integration of good farming practices."

Components of an IPM Program

Success in IPM requires a good understanding and application of the following key elements:

- Preventing organisms (weeds, insects, diseases, vertebrates, etc.) from becoming pest problems by planning and managing their environment.
- Identifying pests and beneficial species and understanding their life cycles.
- Monitoring pest and beneficial species, pest damage and environmental conditions.
- Using injury and action thresholds (often called economic thresholds) to determine when to treat pests.

- Using treatments that include a combination of methods such as cultural, biological, physical, mechanical, behavioral or chemical methods to achieve acceptable control with minimal impact on the environment.
- Evaluating the effects and effectiveness of the pest management strategies.

IPM also involves communicating with employees, customers, agencies and the public to inform them of the goals, methods, results and benefits of using IPM.

The **advantages** of using an IPM program are that it can help to:
- provide long term solutions to pest problems
- protect the environment and human health by reducing pesticide use
- minimize harm to beneficial organisms that control pests
- slow down or eliminate the development of pesticide resistant pest populations
- provide pest control options where pesticides cannot be used

Prevention

A well developed IPM program emphasizes making changes in the management of crops and/or livestock, and in the design of the farm environment to prevent pest problems from occurring.

Many of the pest treatment methods categorized as cultural or physical could also be considered preventive, for example, selecting disease or insect resistant plants, managing growing conditions to produce healthy crops, cleaning to eliminate food sources for pests or screening buildings to keep out pests.

IPM Treatments

The first goal of IPM is to prevent the problem. If unsuccessful, the next goal is to limit damage. Prevention involves encouraging natural enemies of the pest, monitoring populations and using or switching to resistant crops before pest numbers increase to cause significant damage. Some chemical applications and sanitary measures to prevent pests and weeds from infesting your farm are very useful (i.e., clean, disease-free treated seed).

Controls are needed when prevention fails or when the nature of the pest makes prevention unsuitable (migratory pests, for example). Controls may include destroying the crop and the pest, spraying, burning, introduction of biological agents or erecting mechanical barriers, such as predator proof fencing. In addition to preventive measures, an effective pest management program uses the best combination of five basic treatments:

1. Cultural
2. Mechanical and physical
3. Biological
4. Behavioral
5. Chemical (pesticides)

1. Cultural Treatments

Cultural controls involve changing your management practices to make the environment unfavorable for pest reproduction, dispersal, and survival.

The following are examples of cultural tactics you can adopt:

- Rotating crops to prevent the build-up of disease and insect populations. Proper rotation is more than merely changing crops. Crops in the rotation must not be hosts for pests that attack other crops in the rotation.
    - For example, seed a cereal on canola stubble to prevent build-up of blackleg.
- Tilling the soil to kill weeds.
- Planting well-adapted, competitive crops.
    - For example, canola is more competitive with weeds than flax.
- Sowing pest resistant varieties or immune species.
    - For example, solid stemmed wheat varieties that resist wheat stem sawfly; cereal varieties resistant to rusts and smut.
- Delaying seeding and control one flush of weeds by tillage.
- Modifying habitat to enhance the activity and survival of natural enemies.
    - For example, planting windbreaks provides habitat for parasites and predators of pests.
- Adjusting the time of planting or harvesting to avoid or reduce pest damage.
    - For example, late seeding is a common practice to enhance weed control. In winter wheat, late seeding reduces damage caused by wheat streak mosaic, barley yellow dwarf and Russian wheat aphid.
- Following good water and fertilizer management practices so the crop can compete more successfully against all pests.
- Encouraging vigorous crops that are able to withstand pest damage by correct and timely seeding, good seeding practices, and selecting crops and varieties adapted to your area.
- Use trap crops to prevent spread of (or to confine) the pests.
    - For example, grasshoppers can be confined to an early seeded strip around the outside of a field and sprayed there instead of spraying the whole field.

Cultural control also involves conducting good sanitary practices which includes removing or destroying infestation sources, pest habitat, breeding and over-wintering sites so pests cannot survive, increase, or spread.

Other examples of sanitary approaches you can take include:

- Cleaning up patches of weeds to prevent spread to the rest of the field.
- Destroying plant refuse, which harbors pests.
    - For example, turn over canola stubble and follow with shallow cultivation to destroy blacklegs' reproductive cycle.
- Eliminating "hosts" in the fall so insects and diseases cannot survive the winter.
    - For example, fall control of volunteer winter wheat eliminates the wheat curl mite, which carries wheat streak mosaic.
- Planting clean seed so weeds and diseases are not introduced.

- Destroying volunteer plants to reduce the survival rate of some plant disease in non-crop years or areas.
  - For example, control volunteer canola in cereals to reduce disease of canola in that field.
- Removing breeding sites, such as manure, will control 70 percent of the fly problems on a farm.
- Washing your hands and disinfecting clothing and boots to prevent transmission of many plant and animal diseases.
- Sterilizing equipment and storage facilities to prevent the spread of diseases such as bacterial ring rot of potato.
- Cleaning out grain bins before filling them with new crops to control grain beetles, bunts in wheat, and covered smut in barley.
- Testing seed for disease and treating or destroying infested lots. Most diseases are invisible and dormant on the seed, such as loose smut of wheat and barley.

2. Mechanical and Physical Treatments

Mechanical and physical treatments are treatments that use equipment or manipulate the environmental factors such as temperature or humidity to prevent the spread of pests or reduce pest populations.

Following are some examples of physical treatments you might use:

- Lightly harrow after crop germination but before emergence (in the same direction as drill rows) to control seedling weeds.
- Use fallow or partial fallow to control weeds.
- Use temperature manipulation for stored grain pests, greenhouse pests, and hay pests.
  - For example, heat treatment of hay destined for Japan is being used to ensure freedom from Hessian fly; and pasteurization or sterilization is commonly used to eliminate weeds, insects, and diseases in greenhouse soils.
- Use traps, nets, fencing and noisemakers to prevent or control damage by problem wildlife such as coyotes, waterfowl, or blackbirds.
- Use perforated culvert pipes to manage beaver flood problems.
- Use screens on irrigation intakes to reduce weed seed spread.
- Install screen windows to keep insects out of the greenhouse.
- Use sticky materials on trees or windows to catch or exclude insects such as houseflies.
- Wash houseplants to control pests.
- Mow weeds.
- Use tillage to destroy weeds and insects or bury plant residue containing disease organisms.
- Use traps to attract and kill mosquitoes and other biting insects.

3. Biological Treatments

Biological control uses living organisms to control pests.

Following are examples of biological practices that you might consider:
- Introduce biological control agents such as specific insects to patches of weeds.
- Ensure you do not kill beneficial species with pesticides.
  - For example, spraying for aphids also kills ladybird beetles, an aphid predator. Spraying could actually reduce control if the natural predators are also eliminated.
- Graze sheep on patches of weeds.
- Use guard animals to protect livestock from predators.
  - For example, guard dogs and donkeys are gaining acceptance in Alberta.
- Muscovy ducks have been used successfully to control houseflies in dairy barns.
- Geese are used to control weeds in strawberries.

Introducing parasites and predators involves careful planning since they are effective only in certain locations and times and may have an impact on crops or animal hosts that are not pests.

4. Behavioral Treatments

These treatments include taking advantage of a pest's natural behavior to suppress populations.

This includes:
- Using pheromones to disrupt mating patterns or attract pests to a trap;
- Releasing sterile males to inhibit pest population.

5. Chemical Treatments

Chemical controls include the use of natural and synthetic pesticides to kill, attract, repel or alter the growth of the pests. The pesticide is applied directly to the pest, to its host, or to the medium in which the pest lives. Use chemicals that are as target-specific as possible in order to minimize impacts on the environment and non-target organisms.

The following are examples of chemical approaches:
- Insecticide application for grasshopper control
- Herbicide application to control weeds such as wild oats
- Fungicide applications to control seed borne and leaf diseases
- Rodenticide baits to control rats, mice and gophers
- Use of pheromones to interrupt the ability of pests to reproduce
  - This practice is used in B.C. to control codling moth. Pheromones are more compatible with the IPM concept than broad-spectrum pesticides.
- Treating seed with insecticides before planting to control insects that live in the soil.

Pesticides are categorized according to their properties such as selective, non-selective, residual, persistent and non-persistent.
- Selective pesticides are toxic to some pests but have little or no effect on other pests or non-target organisms
  - For example, 2,4-D is a selective herbicide because it only controls broadleaf weeds.

- Non-selective pesticides are toxic to a wide range of pests, beneficial species and other non-target organisms.
  - For example, glyphosate (Round up®) is a non-selective herbicide because it kills a wide range of plants.
- Residual pesticides continue to be effective on a treated surface or in the treated area for an extended period following the application (long term control)
  - For example, picloram (Tordon 22K®) is a residual herbicide because it controls all broadleaf weeds that are present or emerge in the area it was sprayed for more than one season.
- Persistent pesticides are those that remain active in the environment for a long time. Sometimes they can accumulate in animal/plant tissues.
- Non persistent pesticides do not remain active in the environment for more than one season or one year.
  - For example, Ally Toss-N-Go™ (metsulfuron-methyl) only controls existing weeds. New weeds that sprout in the area will not be controlled.

When considering the use of pesticides, it is important to determine:

- The pest that the manufacturer claims the product will control.
- The area of use including the crop, animal, or site for which the product is intended.
- Method and rate of application.
- Compatibility with other products or pesticides.
- Phytotoxicity, staining problems, or other injury.
- Mixing and loading instructions.
- Application limitations (re-entry or pre-harvest intervals) and proper timing of the application.

Keeping records of your pesticide applications is extremely important. .It will assist in developing a good IPM program and help determine the cause of lack of control when using pesticides.

The following is a guide to the information you should record.

- The date, time and location of the application.
- The crop variety, seeding date, harvest date, fertilizer type, seed treatment rate and dates, and types of cultivation.
- A complete description of the pest population, age, and type.
- The application equipment, nozzles and pressure used.
- The type of pesticide and rates of any treatments and the total amount of pesticide used.
- Weather including wind speed and direction, temperature and relative humidity, pre- and post-treatment.
- Success of management tactics used to control the pest.
- Reminders of miscellaneous observations and future considerations.
- Yield results.
- Long-term field histories and rotations.

Pest Resistance

Resistance is the ability of a pest population to survive application of a pesticide at the rate registered for control of that pest.

When resistance occurs, a pesticide that may have been effective against a particular pest no longer provides satisfactory control. Some producers may attempt to achieve control of the pest by increasing the pesticide application rate, but this will result in increased selection pressure and will actually speed up the development of resistance. If the resistance cannot be prevented, it is important to slow its development in order to prolong the life span and efficacy of current pesticides. If pest population resistance is not managed properly, it can become very difficult and sometimes impossible to achieve effective control of the pest with pesticides.

The development of resistance is a major concern and will force agricultural producers to adopt better pest management strategies. Reducing pest exposure to pesticides reduces the chances for resistance to develop. Resistance to biological, physical, or any control, except prevention, can also develop, but chances of resistance developing are reduced if a large number of different control techniques are used.

How Pesticide Resistance Develops

Resistance begins with just a few (maybe only one) unique individuals that have been exposed to a pesticide. They possess the natural genetic ability to survive pesticide treatment, even though the pesticide is registered for control of that species.

Every time a resistant individual survives spraying and reproduces, it produces more resistant individuals. In years that follow, these individuals also survive pesticide treatment and continue to reproduce. Over time, the resistant population spreads. Suddenly, resistant pests infest many areas and become a very serious problem.

Herbicide Resistance in Weeds

Resistance is related to the mode of action or the way herbicides control weeds. Once a weed develops resistance to a particular herbicide, chances are that it will also be resistant to other herbicides with a similar mode of action.

Some weeds can develop resistance to herbicides with different modes of action. Scientists who study herbicide resistance have found a common thread in most cases: The herbicide involved was effective initially and the farmer applied it to the field year after year. Continued use of that herbicide selected for resistant weeds and allowed them to spread.

Important Resistance Clues

The following clues indicate that herbicide resistance is developing:

- You have used the same herbicide, or herbicides that have the same mode of action, on the same field for many years.
- Initially, a particular herbicide was very effective; however, it suddenly loses its effectiveness on one particular weed species.
- The resistant weed is found growing in patches. Eventually the weeds spread throughout the field.
- The herbicide continues to control weeds except for the resistant species.

Herbicide Groups

Although rotating herbicides is one way to prevent the development of resistant weeds, it must be done properly. Several herbicides may control weeds in the same way. Both Hoe-Grass II™ and Poast Ultra™, for example, control weeds by the same mode of action. A weed resistant to

Hoe-Grass II™ is therefore likely also to be resistant to Poast Ultra.

Rotating herbicides is an excellent strategy to combat resistance. The key, however, is to rotate herbicide groups, not just herbicides with different brand names. By rotating herbicide groups, you use products that control weeds in different ways. Information on herbicide groups can be found in the following publications:

- Crop Protection 2008 ("Blue Book"), AGDEX 606-1
- How Pesticides Work, AGDEX 606-2

Weed resistance in Alberta was first discovered in the mid-1980s. In 1989, seven cases of resistance to triallate (Avadex BW) were confirmed. Since then, weeds resistant to such herbicides as Avenge (group 8), Fortress (groups 3 and 8), Glean (group 2), Hoe-Grass (group 1), Rival, and Treflan (group 3) have been found. Herbicide resistant weeds now exist throughout the province.

Resistant Weeds

Herbicide Group	Weeds
Group 1	Green foxtail, wild oats
Group 2	Ball mustard, chickweed, cleavers, hemp nettle, kochia, Russian thistle, spiny annual sowthistle, stinkweed, wild mustard, wild oats
Group 3	Green foxtail
Group 4	Hemp nettle
Group 8	Wild oats
Group 1 + 2 + 25 (multiple resistance)	Wild oats
Group 1 + 2 + 8 + 25 (multiple resistance)	Wild oats
Group 1 + 3	Green foxtail
Group 2 + 4	Cleavers

Resistance-Control Strategy

Keep records for every field. Include crop seeded, pesticide(s) applied, date and time of application, rate, weeds present and degree of control, and any other information you want to record.

Use a variety of treatment methods to reduce your reliance on pesticides.

Use pesticides only when monitoring shows they are necessary and rotate herbicide groups.

Use herbicide labels to select an effective tank mix that can delay or prevent herbicide resistance.

Inspect fields throughout the growing season for patches of weeds that appear to have survived herbicide treatment.

Pest and Beneficial Organism Identification

Dealing with any pest requires proper identification of both the pest and the beneficial organisms that help keep the pests in check. Incorrect identification could result in wasted money, excessive pesticide use, and unjustified damage to beneficial organisms. Identifying the beneficial organisms and their life cycles provide great benefits as well as it may indicate that treatments are not required if the beneficials are present in sufficient numbers to control the pest at acceptable levels.

Knowing about the biology of both the pest and beneficials helps you to make important management decisions including:

- Knowing the life cycle and growth of pests and beneficials allows you to make treatments when the pest is most susceptible.
  - i.e. there may only be a very short time when a treatment may be effective
- Knowing how rapidly the pest species reproduces helps to determine the timing and number of treatments that may be necessary.
- Knowing how rapidly beneficial species reproduce helps you to decide whether other treatments are needed.
- Life cycle of the host may be important since certain treatments can harm the host if applied at the wrong time.
  - i.e. applying a herbicide when the crop is just emerging may damage it
- Behavior of the pest may influence the timing or choice of treatment.
  - i.e. the pest may only be present at certain times of the day or night or in certain locations

Although you may need a lab to help identify plant diseases, you can learn to identify most other pests yourself. Sometimes it is easier to identify the pest by examining the damage it causes.

Some examples:

- Cutworm damage to cereals is easily identified, but the larva can only be found by digging in the soil surrounding damaged plants.
- Livestock predators are not usually seen making a kill, but their damage is characteristic.
- Wireworms leave potato tubers before harvest, but their presence can be detected by holes in the potatoes.

If you cannot identify the pest, obtain help from:

- Publications in the Alberta Agriculture and Rural Development website at: http://www.agric.gov.ab.ca
- Alberta Agriculture Ag-Info Centre at 1-866-882-7677
- Local crop production specialists or custom sprayer operators
- Local pesticide vendors may also employ crop production specialists
- Community colleges and universities that provide outreach or extension services
- The Internet has many useful websites. Before using the recommendations, make sure they are valid for your region, your soil, weather and cropping conditions and that the pesticides recommended are registered for use in Canada

Recognition of weeds by their life cycle

Based on their length of life, plants may be divided into:

- Summer annuals
- Winter annuals
- Biennials
- Perennials

Summer and Winter Annuals

Plants that complete their life cycle within one growing season or one year are classified as annuals. There are two types of annuals: summer annuals and winter annuals. Summer annuals are plants that complete their life cycle within one growing season. They germinate from seed early in the spring, produce a plant, flower, set seed and die within the span of one season. Winter annuals complete their life cycle within one year, but it spans over two calendar years. Winter annuals germinate in the fall and produce a plant that is able to overwinter. The plant resumes growing the next spring, flowers, sets seed and dies before the end of the next growing season. Winter annuals can act as summer annuals under certain growing conditions.

Summer Annuals			
Spring	Summer	Fall	Winter
Germinate	Grow and Flower	Produce Seed	Die
Winter Annuals			
Fall	Winter	Spring	Summer
Germinate	Dormant	Produce Seed	Die

Prevention of seed production is the strategy used for control of annuals. Shallow tillage prior to crop seeding can encourage germination of weed seeds that are then eliminated during subsequent seeding operations or in crop herbicide applications.

Winter annuals may be controlled with fall and/or early spring tillage. Fall application of 2,4-D or other suitable herbicides to winter annuals will provide excellent control in stubble fields and summerfallow.

Biennials

Plants that complete their life cycle within two years are classified as biennials. Biennial plants produce roots and leaves in the first growing season that are able to overwinter. The plant resumes growth the next growing season and produces flowers and sets seed before dying. Tillage is an effective method of control for biennials. Late fall or early spring tillage will destroy the rosettes before they have an opportunity to send up seedstalks. Biennials sometimes produce seedstalks early in the spring, therefore, early spring tillage would provide the best results for control. Biennials are not well suited to cultivated fields and are generally found on sites that receive little cultivation.

Biennials

First Spring	First Summer	Winter	Second Spring	Second Summer
Germinate →	Rosette → Well-developed Root	Dormant →	Flower →	Produce Seed
			Second Winter Die	

Perennials

Perennials live more than two years and in most situations do not produce seed the first year of growth, but produce seed every year thereafter. Many perennials are also able to reproduce vegetatively. There are two types perennials: creeping perennials and simple perennials.

Creeping Perennials:
Creeping rooted perennials are able to spread either by seed or through their root system. They store large amounts of food reserves in the roots system enabling them to survive adverse conditions. They also form buds along the rhizomes that are able to grow into new plants. Canada thistle is an example of a creeping perennial. It is able to send up new shoots formed from buds along its' extensive creeping root system.

Simple Perennials:
Simple perennials reproduce only from seed. They may have either a tap or fibrous root system. Examples of tap rooted perennials are dandelion and absinth. Wild barley and crested wheatgrass would be examples of a fibrous rooted perennial. Simple perennials have no vegetative means of reproducing but the plant lives for many years.

In some cases perennials can be managed effectively by cutting top growth frequently to deplete the food reserves in the undergound portions. In other cases repeated tillage is more effective. Simple perennials are vulnerable to deep tillage while creeping rooted perennials are often just spread by tillage.

Perennials

First Spring	First Summer	Winter	Second Spring	Second Summer
Germinate →	Grow, Start Rhizomes, Creeping Roots →	Dormant →	Spread Rhizomes, Creeping Roots →	Original Plant Flowers New Plant Grows
			Second Winter Original Plant Dies New Plants Dormant	

Recognition of Insects and their Developmental Stages

Insects are distinguished from other animals, such as spiders and mites by four characteristics. Insects at maturity have the following:

1. Three distinctly segmented body parts
2. Six legs
3. Two antennae
4. An exoskeleton

Spiders and mites are not considered insects because they have eight legs. All insects are segmented into a head, thorax and abdomen. The head bears the antennae, eyes, and mouthparts. The thorax bears wings, usually one or two pairs, and three pairs of legs, while the abdomen contains the digestive and sex organs. Immature insects, called larva or nymphs, do not have these identifying characteristics and therefore an understanding of their growth and development is essential for planning an IPM program.

Insect development or metamorphosis is classified as either complete or incomplete. Complete metamorphosis proceeds through a serious of distinctly different growth forms. Incomplete metamorphosis, also called gradual metamorphosis, proceeds through a number of growth stages in which the young look very similar to the adult.

Complete Metamorphosis

Insects that undergo complete metamorphosis go through four separate life stages:

1. Egg
2. Larva or nymph
3. Pupa
4. Adult

Eggs are laid either singly or in masses from which larva or nymphs emerge. The larval stages, called instars, are when the insect is actively growing and increasing in size. The larva are generally somewhat mobile and are actively feeding at this stage. Upon completion of growth, the larva changes to a non-feeding, resting stage called the pupa (frequently in a cocoon). During the pupal stage the insect transforms into the adult. The adult is the reproductive and mobile stage of the life cycle. Many insects commonly found in crops, such as beetles, flies, moths and butterflies, go through complete development. The larva are often the most damaging stage of these insects to crops. The larval stages are known by various common names.

- **Caterpillars** are the larvae of butterflies, moths (some of which are cutworms) and sawflies. These larvae have six clawed legs at the front of the body and numerous fleshy legs at the rear.
- **Maggots** are the headless, legless larvae of flies.
- **Grubs** are beetle larvae; they have jointed legs and well developed heads.

The wings develop on the larva and can be seen in outline on the pupa. Next time you find cutworm pupae, look at it carefully. You will see the wings outlined. Notice that when it is gently squeezed, the segmented abdomen moves. This is a good way to determine if pupae are alive.

Incomplete or Gradual Metamorphosis

Insects with incomplete or gradual metamorphosis hatch from eggs and go through a series of nymph stages before becoming adults. Nymphs and adults look very similar, except that the adults are larger and normally have wings. There is no resting stage (pupa) in this group; when the mature nymph sheds its skin for the last time it becomes a reproductive adult.

In most species, nymphs have “wing pads” that become wings on the adults. The size of these pads is used to determine the growth stage of the nymph. Since many insecticides are more effective on younger insects, you should determine the stage of the insects you must control. This is done by comparing the size of the nymphs to one another and to the adults, and by noting the size of the developing wing pads.

Pest and Beneficial Species Biology Determines the Control

Once the pest and the beneficial species are identified, study their biology to plan control strategies. Answers to the following questions will help you decide on a control method.

- What specific environmental conditions favor growth of the pest and the beneficial?
- Where do both the pest and the beneficial live?
- How do the pest and beneficial spread?
- How do the pest and the beneficial reproduce and multiply?
- What influences do weather and crop vigor have on the pest and the beneficial?
- What are the damage symptoms of the pest?
- What are the natural enemies of the pest?
- How does the pest damage the crop?
- Does the pest have alternate food sources or does it die in the absence of the host crop?

Good biological information is the basis for designing an effective program to either prevent or minimize losses from pests.

Following are examples of how biological information can be useful:

- Whether an insect has one or many reproductive cycles a year dictates whether one or several treatments will be necessary or whether early treatment will prevent more damage during the next cycle.
- Knowing the seasonal life cycle of a pest helps in anticipating problems and identifying ways to disrupt the cycle (i.e. annual, perennial, and biennial weeds).
- Knowing that pocket gophers feed only on tap-rooted plants means that controlling broad leaf plants in grass fields can be used as a control strategy.
- Knowing the biology of plant diseases that infect plants below ground but cause symptoms above ground helps in identification and control (i.e. root rot).
- Grasshopper survival is greater during warm dry springs than cool moist springs, so watch for them then.
- Leaf diseases spread more rapidly under humid conditions than warm, dry conditions, so increase your inspections accordingly.
- Some organisms are not pests themselves but carry disease. The disease organisms may be microscopic, but you can detect and control the

carrier. For example, aphids spread barley yellow dwarf virus and wheat curl mite spreads wheat streak mosaic virus.
- The diamondback moth does not overwinter in Canada. It comes from the United States every spring so no preventive action is possible. Problems arise late in the season depending on the size of the flight from the United States. Spraying is the only remedy.

Monitoring

Monitoring or field scouting is the process of regularly inspecting crops and recording the pests that are present and their growth stages. Monitoring also includes:
- Recording weather conditions
  - Do they favour pest or beneficial development?
- The host growth stage and condition
  - Is it at the right stage of growth for the management decision being considered?
- Beneficial organisms that are present
  - Are there enough to keep the pest population below the injury or economic threshold?

Monitoring helps to:
- Locate the centre of an infestations so the treatments can be directed at the source.
- Limit the spread of the pest and the number of future treatments that may be needed.
- Find the cause of pest problem which helps to identify actions to be taken to prevent future outbreaks.
- Select and revise action thresholds.
- Assess treatment results.
- Plan improvements that will make the pest management program more effective.

A good monitoring program can:
- Significantly reduce the need for treatments
- Improve the success of the pest management program
- Reduce treatment costs

There are two types of monitoring methods:

1. **Visual inspections**
   - Look carefully for signs of pest problems or conditions that favour pests.
   - Do it regularly and write detailed notes. The value of the observations depends on how much knowledge you have of the pest, beneficials and the crop.

Visual inspections are most useful when checking for:
- Presence or absence of the pests or damage symptoms or beneficial species.
- Growing conditions and health of the crop.
- Environmental conditions that favour the pests or provide them with shelter, food or water.

2. **Counting and measuring methods**
   - These give numerical information about pest and beneficial populations or level of damage.
   - If the same method is followed each time, the results can be compared to counts done at other times and by different people.

Counting methods are useful for:

- Estimating the size and spread of a pest and beneficial population
- Comparing records from other sites or dates
- Establishing injury and action thresholds
- Evaluating effects of treatments on pest and beneficial populations

Items to count or measure include:

- Number of pests or signs of damage on leaves or plants
- Number of pests in a measured area
  - e.g. the number of weeds per square metre
- Number of pests and beneficials caught in a trap
- Size of the infestation
  - e.g. what part of the plant is affected
- Number of days with weather conditions that favour a pest
  - e.g. the number of days where the humidity is higher than 60%

How good this monitoring estimate is depends on:

- Sampling size - how many samples are counted
- Sample randomness – how the samples were chosen and whether they were chosen randomly

Sample Size:

The more samples that are counted, the more likely it is that the results will give a reliable estimate of what is being counted for the whole crop. There is a practical limit to how many samples can be taken, but for acceptable accuracy collect between 10-50 samples. To find out how many samples are needed for accuracy, collect 10 samples and count the number of pests, add up the total for all the counts and divide by 10 to get an average/sample. Then take 40 samples and count the pests and calculate the average/sample. Compare the two averages. If they are within 10-20% of each other, it shows that 10 samples were probably enough because the result did not change when more samples were taken. If the two averages are greater than 20%, then a higher number of samples need to be collected. Try an average of 15, 20 or more until you find the sample number that is within 10 to 20% of the average of the 40 samples.

Sample Randomness:

Samples need to taken randomly to ensure results are not influenced by the person sampling. This means picking the sampling locations by chance without looking at them first and deciding what to take. If the samples are intentionally picked from the most damaged area, the pest situation could appear worse than it really is, or if the samples were only picked from undamaged areas, the pest situation would be underrepresented. To make sure samples are taken randomly decide on a sampling plan ahead of time and stick to it.

Ways to do this include:

- plotting a grid on a map showing where samples will be taken
- taking samples at pre-determined points, such as every fifth plant in a row or at 5 metres along a transect line

Environmental conditions

Observing and recording environmental conditions at the treatment site will help in making treatment decisions. Environmental conditions can influence the effectiveness of a treatment and its safety (environmental and human). Environmental considerations are especially important when considering pesticide treatments, but may be important towards the success of non-pesticide treatments as well. Environmental conditions to monitor include:

- Temperature
  - e.g. a parasite may require certain temperatures to survive or be active; some pesticides require certain temperatures to be effective
- Relative Humidity
  - e.g. some plant diseases will not develop when the relative humidity is low
- Precipitation
  - e.g. rain may reduce the pesticide's effectiveness by washing it off the crop
- Air Movement
  - e.g. wind can spread pests to many areas; wind can also cause pesticide drift and damage to non-target crops
- Nearby Sensitive Areas
  - e.g. adjacent fish bearing water may affect the choice of the treatment method
- Topography
  - eg. steep or rolling land may make pesticide applications very difficult with certain types of application equipment

Below is an example of a typical field scouting form.

<table>
<tr><th colspan="4">Field Scouting Form</th><th colspan="5">Date:</th></tr>
<tr><td colspan="4" rowspan="2">Field Description</td><td>Soil Moisture</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td></tr>
<tr><td></td><td>High</td><td>Good</td><td>Fair</td><td>Poor</td></tr>
<tr><td colspan="4">Crop Variety</td><td>Crop Stand</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td></tr>
<tr><td colspan="4">Crop Stage</td><td></td><td>High</td><td>Good</td><td>Fair</td><td>Poor</td></tr>
<tr><td colspan="9">Species Present</td></tr>
<tr><td>Weeds</td><td>Leaf Stage</td><td colspan="2">Pattern in Field</td><td colspan="5">Symptoms of Chemical Action / Damage</td></tr>
<tr><td></td><td></td><td colspan="2"></td><td colspan="5"></td></tr>
<tr><td>Insects</td><td>Stage Size</td><td colspan="2">Site of Damage</td><td colspan="5">#/Length of Row Area, Plant Part</td></tr>
<tr><td></td><td></td><td>On Plant</td><td>In Field</td><td colspan="5"></td></tr>
<tr><td>Plant Diseases</td><td>Severity</td><td colspan="2">Site of Damage</td><td colspan="5">Description of Symptoms</td></tr>
<tr><td></td><td></td><td>On Plant</td><td>In Field</td><td colspan="5"></td></tr>
</table>

The table below provides examples of symptoms caused by a variety of pests.

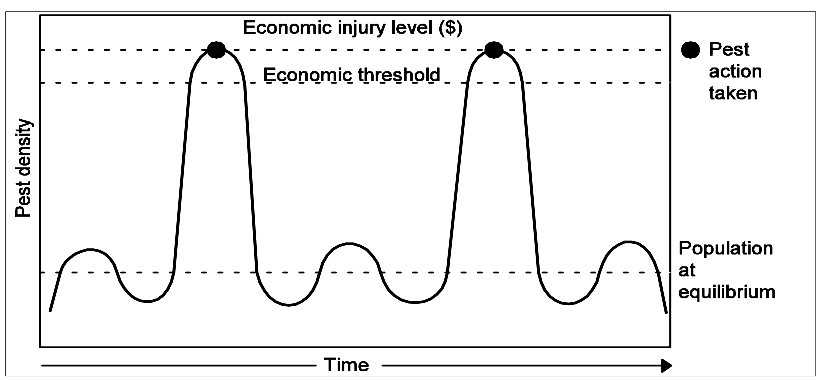
Field Symptoms	Leaf Symptoms	Stem Symptoms	Flower & Fruit Symptoms	Root Symptoms
Spotty	Yellowing	Twisting	Wilting	Inhibition
Yellowing	Cupping	Kinking	Deformation	Tunnelling
Browning	Loss of leaves	Breaking	Arrangement	Rotting
Loss of vigor	Rolling of leaves	Elongating	Missing	Swelling
Stunting	Crinkling	Shortening	Branching	Chewing signs
Thinning associated with topography	Feathering	Cracking	Delayed development	
Poor germination	Chewing signs	Spotting	Clipping	
Kinking, lodging	Striping	Swelling		
	Blotching	Puncturing		
		Rotting		

Injury and Action Thresholds

Deciding when to apply treatments involves using monitoring information to determine the injury threshold, often called the economic threshold, and the action threshold, also called treatment threshold for implementing an action or treatment level for a pest.

The injury threshold is when a pest population reaches numbers that it causes unacceptable injury or damage; numbers are sufficient enough to justify treatment. A few individuals of a pest population can usually be tolerated. Treatments should only be considered if numbers increase to, or are likely to increase to, the injury threshold. Pest treatments cost money and may have other impacts on wildlife, fish habitat or beneficial species. Consider these impacts as well when determining whether or not the treatment is justified.

The action threshold is the point at which treatment should take place in order to prevent the pest population from reaching the injury threshold. The action threshold depends on the type of treatment, the life cycle of the pest and how fast the pest is reproducing.



Information for helping to establish the injury and action thresholds is available from:

- Crop Protection Book, published by Alberta Agriculture and Food

- publications in the Alberta Agriculture and Rural Development website at: http://www.agric.gov.ab.ca
- Alberta Agriculture Ag-Info Centre at 1-866-882-7677 to talk to a crop or pest specialist
- Community colleges and universities that provide outreach or extension services
- Grower organizations

Decision Making in IPM

Treatment selection requires careful analysis of the information regarding the pest, beneficials, crop, monitoring results, injury and action thresholds, environmental conditions and the treatment options. Treatments should be selected that are:

- Least hazardous to human health
- Least toxic or otherwise least damaging to crop and adjacent sensitive areas, the land and the environment
- Most likely to produce long-term improvements
- Most cost effective over time

In an IPM program, usually, several treatment methods are used in a coordinated approach. Using a combination of treatment methods is usually more effective than relying on only one method. If a pesticide is to be used, it must be evaluated based on its compatibility with other treatments. For example, if an insect is a pest, choosing a broad spectrum pesticide to control the pest will not likely be compatible with cultural treatments that use natural predator and parasitoids.

For all pest treatment actions, detailed information should be recorded on the treatments and equipment used, timing, rates (e.g. pesticide, amendments and fertilizer rates) and weather conditions. This information is important for the evaluation step in an IPM program.

Evaluation

Evaluation is used to:

- Evaluate the effectiveness of the pest management program
- Modify and improve the pest management program, including actions to prevent pests
- Anticipate and plan for pest infestations
- Keep track of costs and benefits of the pest management program

Evaluation involves:

- Making post-treatment observations on pests, beneficial and non-target organisms
- Comparing post-treatment observations with pre-treatment monitoring records to determine treatment effects
- Reviewing treatment records, including methods, dates, times, rates, costs, etc.
- Identifying improvements to pest management that can be made, including preventative actions that can be taken

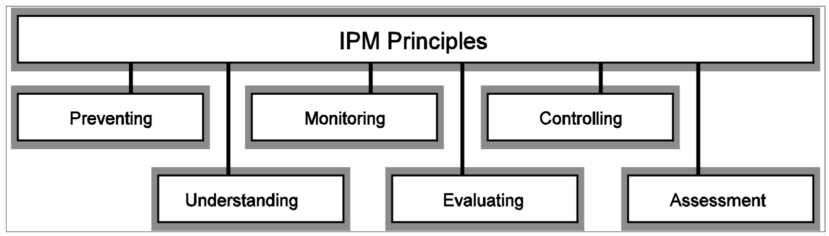
Communication

Contacts and communication with other farmers, local pest experts, government specialists, grower groups and other people practicing IPM is essential for continuing to gather valuable information to improve the success of your IPM program. Details of the IPM program also need to be shared with everyone on the farm, so they will not inadvertently jeopardize any aspect of the program. Everyone needs to know what their roles are and how they can contribute to the success of the program.

Lastly communicating about your IPM program to buyers and the public is also very important for success of both the program and for acceptance by the public, especially adjacent land owners, acreage owners and urban residential people living close to you.

Summary

Many sound IPM programs are already being used to deal with pests. In an IPM program, treatments are combined to make them more effective, less costly, environmentally sound and sustainable over a long term. Integrated pest management is based on a set of principles:



Understanding the pest, its biology, habitats, and relationship to the crop enables you to make sound management decisions.

Prevention, involves using sanitary and cultural tactics, including resistant varieties, cultivation, rotation, and other methods to keep pests from becoming a problem.

Monitoring pest levels and growth conditions relative to environmental conditions allows you to assess the need for, and timing of, application of control tactics.

Recording filed histories, treatments, and pests over time.

Evaluating results by using economics to make control decisions, not “visibility thresholds,” hearsay, pressure from neighbors or custom applicators. Compare the costs and risk of controls to the cost of not taking action – economic thresholds.

Controlling pests by using the approach that best satisfies society and agriculture’s needs.

Planning occurs by reviewing and assessing records that enables you to make decisions for the next pest problem.

Changes I Need to Make

I will keep the following information:

- ☐ Crop variety
- ☐ Seeding date
- ☐ Harvest date
- ☐ Fertilizer type
- ☐ Seed treatment rate
- ☐ Dates and types of cultivations
- ☐ Description of pest population, age, and type
- ☐ Environmental conditions before and after treatment
- ☐ Success of the pest management treatments
- ☐ Observations and future considerations
- ☐ Long-term field histories and rotations

Before applying a control practice, I will determine:

- ☐ How the pest grows under specific conditions
- ☐ How the pest survives and lives
- ☐ How the pest reproduces and multiplies
- ☐ What influences weather and crop vigor have on the pest
- ☐ Damage symptoms
- ☐ Natural enemies
- ☐ The method by which the pest damages the crop

Review Checklist

- ☐ I understand how pesticide resistance develops.
- ☐ I can list four clues that identify a herbicide-resistance problem.
- ☐ I understand how rotating herbicide groups can prevent or delay herbicide resistance.
- ☐ I can give five examples of prevention practices to deal with pests.
- ☐ I can give five examples of cultural practices to deal with pests.
- ☐ I can give five examples of mechanical/physical practices to deal with pests.
- ☐ I can give five examples of biological practices to deal with pests.
- ☐ I can give five examples of chemicals to deal with pests.
- ☐ I understand the concept of injury (economic) and action thresholds.

If you can not check off the above items, review the appropriate sections.

Exercises

Exercise 5.1

Check the box indicating the correct statement in each part.

1. ☐ a. Scouting is a process of occasionally inspecting a crop to determine if pests are present and if the crop is at a growth stage suitable for treatment.

   OR

   ☐ b. Scouting is a process of regularly inspecting crops to determine if pests are present, what growth stage they are at, and recording the information for future or current management decisions.

2. ☐ a. Field maps should be prepared to record treatments so that in an event of a failure of a pesticide to control the problem a farmer has some basic information to aid in determining the reason for failure.

   OR

   ☐ b. Field maps and scouting records should be prepared to record the extent of the pest problem, the pest and beneficial organisms present and any chemicals applied so that future cropping plans can be based on this data.

3. ☐ a. The crop variety, soil moisture, numbers of weeds/m^2 and whether a crop is underseeded **are not** essential data when making a control decision.

   OR

   ☐ b. The crop variety, soil moisture, numbers of weeds/m^2 and whether a crop is underseeded **are** essential data when making a control decision

4. ☐ a. A farmer should record environmental conditions and crop growth because they influence pest management decisions.

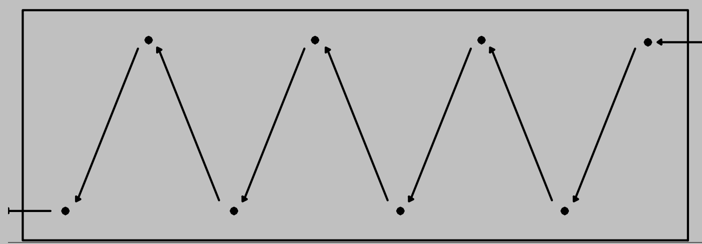
   OR

   ☐ b. A farmer does not need to record environmental conditions and crop growth because factors influencing pest management decisions are so complex the situation will change anyway.

5. ☐ a. The scouting pattern below would be useful for uniformly distributed pests such as stinkweed, wild oats, blackleg of canola, bertha armyworms, diamond back moths, lygus bugs, root maggots and leaf diseases.

   OR

- [ ] b. The scouting pattern below would be useful for unevenly distributed pests or pests concentrated at field edges such as thistles, quackgrass, scentless chamomile, tansy, cutworms, grasshoppers and root rot.



Exercise 5.2

Mark each statement True (T) or False (F).

- [ ] a. Proper identification of a pest and knowledge of its biology are essential in IPM to ensure correct controls are used to manage the pest.
- [ ] b. Identification of a pest's natural enemies is not important in IPM.
- [ ] c. Knowing how a pest reproduces does not help in making IPM decisions.
- [ ] d. Good pest management decisions can be made without a good knowledge of a pest's biology.

Exercise 5.3

Mark each statement True (T) or False (F).

- [ ] a. Planting resistant crop cultivars is a preventative pest control tactic.
- [ ] b. IPM stands for Integrated Pest Management.
- [ ] c. Large animals such as dogs and sheep and beneficial insect parasites can be used as pest management tools.
- [ ] d. Integrated pest management is a system that requires a farmer to make more complex decisions and have more knowledge.
- [ ] e. Any pest control practice including the use of pesticides can be part of an IPM approach.

Exercise 5.4

a) List five IPM methods you are currently using

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________

b) List five IPM methods that you could foresee using in the future

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________

Exercise 5.5

Mark each statement True (T) or False (F).

- ☐ a. Rotating herbicides is an effective means to prevent herbicide resistance.
- ☐ b. Herbicide groups are based on their mode of action.
- ☐ c. All herbicides within a herbicide group control the same weeds.
- ☐ d. Tank mixes control a herbicide resistant weed.

Exercise 5.6

Think about how you could use some of the techniques mentioned here to make practical modifications to your farming techniques. Write a few ideas in the space below.

____

____

____

____

Answers

Answer 5.1

1. b
2. b
3. b
4. a
5. a

Answer 5.2

a. True
b . False
c. False
d. False

Answer 5.3

a. True
b. True
c . True
d. True
e. True

Answer 5.5

a. True: But you must rotate herbicide groups. Herbicides that belong to the same group have the same mode of action. A weed resistant to that mode of action is resistant to every herbicide in that group.
b. True
c. False: See herbicide labels for weeds controlled.
d. True: But only if the herbicides in the tank mix belong to different groups and therefore have different modes of action on the resistant weed and are registered for control of the resistant weed.