

# Pack 111-10

# Type: Backgrounder

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**Backgrounder: Integrated pest management (IPM)**

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**Introduction**

Integrated pest management or IPM emerged in the 1940s and 1950s with the recognition that overreliance on chemical (or synthetic) pesticides can cause environmental problems.

This backgrounder defines IPM, introduces the principles of IPM, and uses examples from managing various insect pests to illustrate the principles.

A pesticide can be defined as “a substance used to destroy or prevent insects or other organisms harmful to cultivated plants. It includes, among others, insecticides, fungicides, and herbicides. It includes chemical pesticides and biological pesticides (biopesticides).”

The need for an IPM approach in Africa is underlined by the fact that, according to a recent study, approximately 20% of the active ingredients in pesticides registered in 14 African countries fall into the FAO category of “highly hazardous pesticides”, which, among other criteria, can have acute or chronic toxic effects and “pose particular risk to children.”

Industrialized countries have y banned or strongly restricted many of these pesticides. African farmers don’t often wear personal protective equipment, and have little awareness of how to safely handle pesticides, for example, safe storage and safe disposal of empty pesticide containers and packaging. Pesticide poisonings and hospitalizations are common in some regions. The costs to society from issues like damage to human health from pesticide use can be high; in Mali, the costs were estimated in 2002 at 40% of the costs paid by farmers for pesticide products. Also, pesticides generally kill the natural enemies\* that manage pests. This can cause pest populations to rebound to higher levels than before farmers applied pesticides, and result in a vicious cycle (also called the “pesticide treadmill”) in which farmers must use greater and greater volumes of pesticide to achieve adequate control, which results in insect pests developing resistance to individual pesticides or whole classes of pesticides.

***Why is integrated pest management important to listeners?***

* It provides effective and longer-lasting management of pests.
* Safety: IPM may involve using less toxic chemical pesticides, but IPM is safer for farmers and the environment than approaches that rely on synthetic pesticides as the main approach to pest and disease management.
* It is economical, because farmers do not spend money using pest control measures that cost them more than they save.
* It teaches farmers about the agroecology\* of their own farm.

***What is IPM?***

* IPM is an ecosystem-based approach to pest management that focuses on long-term prevention of pests by using a combination of techniques, including biological control, manipulating field habitat, modifying production practices, and using resistant varieties. In IPM, control methods are used only if monitoring indicates that the costs of not acting will be greater than the costs of acting, and pesticides are used only if safer and equally effective measures are not possible.

***What are some key facts about IPM?***

* IPM relies strongly on regular monitoring to determine if treatments are needed and when they would be most successful.
* If treatment is needed, IPM uses physical, mechanical, cultural, and biological methods to keep pest numbers low enough to prevent unacceptable damage. If pesticides are used, least-toxic materials are applied as a last resort with the goal of removing only the target organism, and applied in a way that minimizes risks to human health, to beneficial and non-target organisms, and to the environment.

***What are the big challenges of IPM?***

* Getting farmers to accept the idea that they can reduce or even eliminate pesticide use without losing yield and/or income.
* An IPM approach may be more complex than what farmers are used to. For example, farmers may apply synthetic pesticides when they first see a pest or evidence of pest damage, or spray on a calendar basis. Even if yield and income are comparable when using an IPM approach, farmers may not be willing to apply the effort required to understand and implement IPM.
* Advice that farmers receive from, for example, agro-input retailers may be biased towards using synthetic pesticides to the exclusion of other approaches, and may even suggest applying them on a calendar basis. Retailers have a built-in incentive to sell inputs.
* Biopesticides may not be available in many areas.
* Insufficient training and technical support to farmers.
* Lack of favourable government policies and support.
* Lack of investment in research related to IPM.
* Prominence of pesticide-based solutions.

***Is there misinformation about IPM that I should cover?***

* That IPM is too difficult for farmers to understand.
* That IPM is expensive to implement.
* That IPM will not lead to gains in yield and income.
* That there are individual practices or a specific set of practices which are “IPM practices.” (In fact, IPM is an *approach* to pest management, and can include any safe and effective pest management practice.)

***Gender aspects of IPM***

* Women are more likely to be involved in weeding, control of vertebrate pests (for example, rats), and cleaning, sorting, and storing produce. Agricultural research and extension has generally neglected women and “women’s crops,” including family food crops. Therefore, not as many innovative practices may be available for these kinds of activities and these crops.
* Women farmers face significantly more time constraints because of their multiple workload—farming work, household chores, and care for the family. Thus, some practices which are common in IPM programs (e.g., detailed pest monitoring and manual egg removal) are too labour-intensive and time-consuming to be well suited to women farmers.
* Women farmers are much less likely to access information about IPM.

***Predicted impact of climate change on IPM***

Threats from climate change include:

* Increases in pest populations and changes to pest life cycles.
* Invasion by introduced or migrated alien species of plants or animal pests.
* Reduction of crop tolerance or resistance to pests and disease.
* Increase in food toxins such as aflatoxin, and appearance of new strains of toxin-producing fungi.
* Loss of some wild relatives of crops that could be used in plant breeding programs to introduce characteristics that would boost pest or disease resistance.
* Decrease in soil fertility and increase in soil erosion, which reduces the natural capacity of soils to control soil-borne pests and diseases.
* Reduction of beneficial organisms (for example, predators\* and parasitoids\*) for pest and disease control.
* Reduction in the effectiveness of pesticides.

**Key information about IPM**

There are many ways to understand how IPM works. One way is to think of IPM as a six-step process. These six steps are not always chronological, and often overlap.

1. Identify pests.
2. Monitor and assess pest numbers and damage.
3. Follow economic threshold or injury levels that recommend when management actions are needed.
4. Prevent pest problems whenever possible, with the understanding that preventative management is best.
5. When necessary, use a combination of biological, cultural, physical/mechanical, and chemical tools.
6. After taking action, assess the impact of pest management activities.
7. **Identify pests**

Correctly identifying a pest is key to knowing a) whether it is likely to become a problem and b) the best way to manage it.

Mistaken identification may result in ineffective or even damaging actions. For example, farmers could misidentify plant damage due to overwatering as a fungal infection.

Once you correctly identify a pest, knowing its lifecycle will help you decide if management actions are necessary, and the best times to use management actions.

*Identifying Fall armyworm*

*Egg: Eggs are round, and change colour from green to light brown before hatching in 2-7 days. The adult female lays egg masses on the surface of lower leaves that contain about 150-200 tiny eggs covered in a felt-like layer of grey-pink scales. Each female can lay more than 1,000 eggs in her lifetime.*

*Caterpillar (larva) : Caterpillars are the life stage that cause damage to plants by feeding on soft plant tissues. Fall armyworm caterpillars have stripes down the length of their bodies and dark heads with a pale, upside-down Y-shaped marking on the front. They also have four dark dots on the eighth segment of their bodies. As they mature, Fall armyworm caterpillars change from light green to dark brown. They are at their most damaging when they are 3-4 centimetres long. When feeding, larvae excrete big lumps that are visible on leaf surfaces. Only one larvae is usually present feeding in the leaf whorl. Caterpillars take 2-3 weeks to mature, and then change to pupa.*

*Pupa : The pupa is shiny brown and usually underground. If the soil is too hard, larvae may web together leaf debris and other material to form a cocoon on the surface of the soil. The pupa spends 9-13 days inside a loose cocoon, then emerges from the cocoon as a moth.*

*Adult moths : Female moths are slightly bigger than males. The male forewing is mottled (light brown, grey, and straw-coloured), and the female has light colouring. The gray colour makes the moth difficult to see, especially when resting near or on the ground. Adults emerge at night and females use the period before egg laying to fly for many kilometres before settling to lay eggs. On average, adults live for 12-14 days.*

*It may be difficult for an untrained eye to easily tell the difference between Fall armyworm and other armyworms in the field. But there are differences if you look closely. Check:*

* *Does it have a dark head with a pale, upside-down, Y-shaped marking on the front (see circle in diagram and photo 6 in the linked document)?*
* *Do each of the body segments have a pattern of four raised spots when seen from above (see circle in diagram in linked document)?*
* *Does it have four dark spots that form a square on the second-to-last body segment (see circle in diagram and photo 5 in the linked document)?*
* *Is its skin smooth to the touch?*
* *Is the excreta of the larva in the form of large coarse clumps?*

*If the answer to these questions is yes, it is a Fall armyworm caterpillar.*

*See:* [*http://scripts.farmradio.fm/radio-resource-packs/109-farm-radio-resource-pack/backgrounder-fall-armyworm-updated/*](http://scripts.farmradio.fm/radio-resource-packs/109-farm-radio-resource-pack/backgrounder-fall-armyworm-updated/)

1. **Monitor and assess pest numbers and damage**

Monitoring means checking your field to identify which pests are present, how many there are, or how much damage they have caused.

Monitoring should begin as soon as, or slightly before, there is a risk that the pest insect or disease) is present, and it should be conducted regularly. Even small populations of some pests— for example, insects that transmit diseases and some disease microorganisms—can be serious and require early intervention to prevent spread.

Monitoring is best when conducted systematically, for example, by selecting a given number of plants from different areas of the field to ensure that monitoring results are reliable.

Factors such as soil fertility and water quality affect plant resistance to pests and diseases. Farmers can monitor their crops to look for symptoms of nutrient deficiency or imbalances, and to ensure that plants are well developed ahead of the peak period of pest infestation.

If possible, it is also useful to monitor natural enemies to ensure that they are present in sufficient numbers. If not, then measures can be taken to boost their populations, for example by managing the habitat to better support natural enemies. It can be difficult to monitor some natural enemies—for example, parasitic wasps are too small to be seen by the naked eye. But if you see healthy populations of other natural enemies, for example, ground beetles and lacewings, then it is likely that the wasps are also present in good numbers.

*Monitoring for diamondback moth on broccoli, cabbage, cauliflower, and other brassica crops*

*Populations can increase rapidly in warm conditions, so it’s recommended to scout for diamondback moth regularly, at least twice a week. Diamondback moth caterpillars can be detected by visually inspecting the plant and by using pheromone traps, though these traps are not available everywhere.*

*Begin monitoring when plants are young: the earlier you discover the pest, the easier it is to manage. Newly-hatched caterpillars feed****inside the leaf tissue. O****lder caterpillars feed on all parts of the plant, chewing on leaf tissue but leaving the upper leaf surface intact. This type of damage is called****"windowing,"*** *since it creates transparent “windows” on the leaf. In severe infestations, entire leaves can be damaged. You can find caterpillars and pupae on d****amaged leaves, and****older caterpillars often feed around the growing point of young plants. Caterpillars also feed on****stems and pods****. Check plants thoroughly, carefully examining growing points. It is difficult to detect caterpillars that are inside the cabbage head unless you pull back the outer leaves.*

*See:* [*https://www.infonet-biovision.org/PlantHealth/Pests/Diamondback-moth-DBM*](https://www.infonet-biovision.org/PlantHealth/Pests/Diamondback-moth-DBM)

1. **Follow guidelines that determine when management actions are needed or not needed.**

After monitoring and considering information about the pest, its biology, and environmental factors, you can decide whether the pest can be tolerated or whether it is a problem that requires management.

This includes checking monitoring results against *economic thresholds*. Economic thresholds are usually expressed as pest density. Here’s one example of an economic threshold: “evidence of pests or damage from pests in 20% of 100 randomly selected plants in at least five different parts of the field.” This economic threshold is the “break-even point,” the point at which the cost of not taking action equals the cost of taking action.

Establishing an economic threshold is a complex process that involves extension and research staff. But once the threshold has been crossed, action needs to be taken to manage the pest.

If management is needed, the information you have about the pest, its biology, and environmental factors helps you choose the most effective management methods and the best time to use them.

*Fall armyworm in maize:*

*Between germination and flowering, farmers should use control practices only if at least 2 in 10 plants show signs of recent damage. If less than 2 in 10 plants show damage, the cost of using control products outweighs the economic benefit of reducing the pest population. Using pesticides at this stage is also harmful to any natural enemies that might already be attacking Fall armyworm eggs and larvae.*

*After flowering, use control measures only if at least 4 in 10 plants show signs of recent damage. If less than 4 in 10 plants show damage at this stage, the cost of using control products is higher than the economic benefit of reducing the pest population.*

*It is not recommended to use control measures at tassel and silk stage.*

*Always check with your local extension agent to confirm that these thresholds are correct for your location and your crop.*

1. **Prevent pest problems**

IPM includes actions to prevent pests from becoming a problem, such as:

* Growing a healthy crop that can withstand pest attacks.
* Using pest- and disease-resistant varieties.
* Growing crops that are well suited to the environment (for example, not growing crops that need a lot of water in an arid environment).
* Rotating crops to ensure that pest populations do not build up in the field.
* Creating field conditions that do not favour the pest. One way to do this is by intercropping. Intercropping offers pests a less favourable environment for feeding and reproduction.
* Managing the field to attract and protect natural enemies. Natural enemies typically require sources of nectar and pollen aside from feeding on pests. In some cases, planting or retaining plant species that bloom throughout the growing season is a good idea to help keep natural enemy populations healthy.

*For cutworms in cowpea, preventive measures include:*

* *Remove weeds in and around fields to reduce egg-laying sites and help prevent cutworm infestation. Do this at least 2-3 weeks before planting to reduce the incidence of cutworm larvae transferring to newly-planted crops.*
* *Plow and harrow fields properly before planting. This will destroy eggs and expose larvae to chickens, ants, birds, and other predators.*
* *Interplant with onion, garlic, peppermint, coriander, or garlic every 10-20 rows to repel cutworms. You can also plant sunflowers and cosmos as a trap crop in or around fields.*
* *Make protective collars with plastic or paper cups, plastic drink bottles with ripped-out bottoms, or sturdy cardboard. Place the collar around the young plant and push into the soil to prevent cutworms from attacking the stem.*
* *Place sticky substances such as molasses, sawdust, or crushed eggshells around the base of each plant. When the cutworm emerges to feed, it will come in contact with the trap, get stuck, harden, and die.*

*See document at:* [*http://www.oisat.org/downloads/Field\_Guide\_Cowpea.pdf*](http://www.oisat.org/downloads/Field_Guide_Cowpea.pdf)

1. **When necessary, use a combination of biological, cultural, physical/mechanical, and chemical management tools.**

The most effective, long-term approach to managing pests is to use a combination of methods that work better together than separately. IPM uses a combination of the following types of methods:

*Biological tools:* Biological control is the use of *natural enemies*—predators, parasitoids, pathogens, and competitors—to control pests and their damage. It has been estimated that natural enemies account for 50-90% of the pest control that occurs in agricultural systems that are not sprayed with pesticides. Insects, disease organisms, nematodes, weeds, and rodents have many natural enemies. You can modify your field to make it more favourable for natural enemies and/or less favourable for pests. For example, you can plant crops that attract predators and parasitoids of crop pests. Or you could add stakes to your field where insect-eating birds can perch.

*Predators are one type of natural enemy that can keep pest populations in check. They catch and eat other insects and mites, including pest species. Examples of predators include ladybird beetles, dragonflies, predatory mites, predatory bugs, predatory wasps, and spiders.*

*Parasitoids are another type of natural enemy. They lay eggs in (internal parasitoids) or on (external parasitoids) other species of insects, and the larval stage kills the host as it feeds on it and develops. The most common parasitoids are parasitic wasps and flies.*

*Pathogens cause diseases that are fatal or debilitating to insect pests. pathogens include fungi, nematodes, bacteria, viruses, and other microbes.* *Pathogens such as the bacterium Bacillus thuringiensis (Bt) and the fungus Trichoderma viride are commercially available in some countries.*

*There are many ways to encourage natural enemies on your farm:*

* *Provide food sources for adult stages of natural enemies close to the crop, including flowering plants such as fennel, thistles, coriander, Indian mustard, and other flowering brassicas.*
* *Mixed cropping systems provide food and shelter and attract a wider range of natural enemies.*
* *Live fences (trees, hedges) act as windbreaks and provide shelter for natural enemies.*
* *Mulches around plants provide attractive environments for ground-living predators such as beetles and spiders.*
* *To encourage ladybirds, grow non-crop plants which support aphid species that do not attack crops. For example, grow strips of fennel, thistles, coriander, and/or carrots. Avoid spraying pesticides in order not to kill ladybirds.*
* *Adult parasitic wasps feed on nectar, honeydew, or pollen before laying eggs. Keep flowering plants close to, around, and/or within the crop to attract parasitic wasps and provide good habitat for them, including dill, fennel, coriander, nasturtiums, flowering crucifers, sun hemp, clover, alfalfa, parsley, sunflower, and marigold.*

*See:* [*https://www.infonet-biovision.org/PlantHealth/Natural-enemies*](https://www.infonet-biovision.org/PlantHealth/Natural-enemies)

*Cultural tools:* Cultural tools areagricultural practices that farmers can use to enhance crop health and prevent weed, pest, or disease problems without the use of chemical or biological pesticides. These practices reduce pest establishment, reproduction, dispersal, and survival. For example, changing irrigation practices can reduce pest problems, since too much water can increase root diseases and weeds. Intercropping with plants that are less susceptible to a pest reduces the attractiveness of a field to a pest. Trap crops “lure” pests away from the main crop, and can then be uprooted and destroyed.

### *Maize-legume rotations decrease maize’s susceptibility to pests and diseases. The improved nutritional status of the maize plant leads to an increase of African stalk borer attack at early growth stages, but also improved plant vigour, resulting in a net benefit for plant health and yield. Maize intercropped with non-host crops such as cassava and grain legumes can significantly lower stem borer damage and lead to higher yield than mono-cropped maize. Other studies showed that intercropping maize and/or sorghum with cowpeas reduced African stalk borer damage.*

### *See:* [*https://www.infonet-biovision.org/PlantHealth/Pests/African-maize-stalkborer*](https://www.infonet-biovision.org/PlantHealth/Pests/African-maize-stalkborer)

*Physical/mechanical tools:* Mechanical and physical controls either kill pests directly, block them from accessing crops, or make the environment unsuitable for the pest. Physical controls include mulch for weed management, barriers such as screens that keep birds or insects away from a crop, and applying sticky bands to the lower part of tree trunks to stop ants from climbing the tree. Physical/mechanical tools also include handpicking bugs, hosing aphids off plants, and using traps, including pheromone, electric, and light traps.

***For cowpeas:***

* ***Yellow sticky boards:*** Place 1-4 yellow sticky cards per 300 square metres of field area. Replace traps at least once a week. Spread petroleum jelly or used motor oil on yellow painted plywood, 6 cm x 15 cm in size or 30 cm x 30 cm. Place near plants but far away enough to prevent leaves from sticking to the board. Hang traps 60 to 70 cm above plants. Yellow sticky traps are used mainly to monitor for the presence of whiteflies, winged aphids, and leaf mining flies.
* ***Yellow plastic trapping sheets:*** A 2 m x 75 cm yellow plastic sheet coated with motor oil, with both ends attached to bamboo or wooden poles and carried by two persons through the field to mass capture adult flies.
* ***Yellow plastic drinking cups***coated with adhesives and stapled on stakes above plant canopies to trap flies.

*See:* [*http://www.oisat.org/downloads/Field\_Guide\_Cowpea.pdf*](http://www.oisat.org/downloads/Field_Guide_Cowpea.pdf)

*Chemical management tools:* Chemical control is the use of pesticides. In IPM, farmers use pesticides only when needed, and always in combination with other approaches. Individual pesticides are chosen and applied in a way that minimizes possible harm to people, the environment, and non-target organisms (organisms other than the targeted pest). IPM recommends using the most *selective* pesticide (rather than broad-spectrum pesticides) that will do the job and be the safest for other organisms and for air, soil, and water quality. For example, you might use pesticides in bait stations rather than as sprays, or you might spot spray a few weeds instead of an entire area, or use safer products such as insecticidal soaps and pesticides derived from plants or other naturally occurring materials.

Pesticides can be classified by their *modes of action*—in other words, by the ways in which they kill pests or prevent pest damage. Pests sometimes develop resistance to pesticides, which leads to the pesticide being ineffective. This has been the case with hundreds of species of insects, mites, and other pests. Some disease microorganisms have also become resistant to pesticides. To minimize the possibility that pests will develop resistance to individual pesticides or whole classes of pesticides, it is very important to rotate between pesticides that kill or otherwise manage pests in different ways, for example, by interfering with their nervous system or by suppressing pest reproductive or growth processes. Extension officers, input suppliers, and other agricultural experts are potential sources for information about how to pesticides.

*Biopesticides*: A biopesticide is a type of pesticide that is based on a micro-organism or natural products, for example, the bacteria *Bacillus thuringiensis* (Bt), the fungus *Beauveria bassiana*, or the neem tree. In some African countries, some biopesticides are widely available. Most (but not all) biopesticides are safer alternatives to commonly used synthetic chemicals, and, particularly when used as one tool among others in an IPM approach, can be very effective. However, African farmers may not know that biopesticides are available and thus don’t ask retailers for them. And African retailers don’t stock them because farmers rarely request them. Raising farmers’ and retailers’ awareness of biopesticides could help increase their availability and use.

1. **After taking action, assess the impact of pest management activities**

Because the benefits of an IPM approach to pest management are cumulative over time and may not be immediately obvious, it can be somewhat more difficult to evaluate whether the approach is achieving success. However, some of the criteria that can be used to compare IPM with other approaches to pest management are:

* demands on labour and time and for information;
* whether the chosen approach is sustainable, practical, and available;
* longer-term security (for example, with IPM approaches, there is little risk of developing pesticide resistance and the farmer becoming tied to a pesticide treadmill with increasing costs);
* higher yields and increased profit margins;
* simplicity, convenience, and reliability; and
* safety for farmers, their families, and their environment.

After using any kind of pest control methods, farmers should also consider whether they produced unacceptable side effects, and whether to continue, revise, or abandon the methods.

**Successful IPM programs in Africa:**

1. Between 2001 and 2010, the FAO-IPPM program trained 160,000 farmers in Benin, Burkina Faso, Guinea, Mali, Mauritania, Niger, and Senegal. The project focused on two themes: the importance of natural enemies and the ability of plants to compensate for pest damage without using pesticides. Many farmers substituted neem products for chemical pesticides. The programs used Farmer Field Schools to educate farmers about IPM. The costs for implementing IPM were $24 per farmer, and the net benefits were $264 per farmer.
2. In Burkina Faso, Benin, and Mali, 3,500 Farmer Field Schools trained 116,000 farmers on IPM for vegetables, rice and cotton. Pesticide use was cut to 8% of previous use, biopesticides and neem use increased by 70–80%, and there were substantial increases in yields (e.g., in Benin, rice yields rose from 2.3 to 5 tonnes per hectare). In Mali, cotton farmers participating in Farmer Field Schools reduced pesticide use by just over 90% compared with pre-FFS use and a control group.
3. In the early 2000s, a new viral pest transmitted by the sweet potato fly arose in Mali and Senegal, and an IPM project was launched to address it. The IPM program includes avoiding tomato production when whitefly incidence is high, identifying traditional varieties with resistance, and reduced use of chemical pesticides. Sprays have fallen from 7–10 to 2–3 per season, farmers have saved $200 per ha (costs fell from $285 to $85), and yields have risen from 3.3 to 17.5 t/ha. The gains for individual farmers are $3,300 per ha.
4. Push-pull integrated pest management in East Africa: The stem borer is a major pest of maize. Researchers found that: 1) fodder and soil conservation grasses such as Napier grass and molasses grass attract stem borers to lay eggs on the grasses rather than on maize, and 2) legumes such as Desmodium act as repellents, driving stem borers away. Desmodium also fixes up to 100 kg of nitrogen per hectare a year, and releases chemicals from its roots that cause striga seed to germinate and then die. Napier grass releases semiochemicals\* at a 100-fold greater rate in the first hour of nightfall, which is when stem borer moths seek host plants to lay eggs. When the eggs hatch, 80% of the young larvae die because the Napier grass produces a sticky sap that traps the larvae.

In maize-legume intercrops surrounded by these grasses, maize yields increased from 1 to 3.5 tonnes per hectare, and sorghum yields from 1 to 3 tonnes per hectare. The number of farmers using push-pull has increased from a few hundred to 30,000 in the last decade. The push-pull system is economical in part because it is based on locally available plants, not expensive external inputs.

Push-pull also increases livestock productivity because of the increased availability of fodder. Some farmers have now been using push-pull for 15 years and have created many innovations—for example, using upland rice intercropped with Desmodium.

**Where can I find other resources on this topic?**

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**Key definitions**

1. *Agroecology:* The study of ecological processes applied to agricultural production systems.
2. *Ecology*: A branch of science that studies the interrelationship of organisms and their environments.
3. *Economic injury level*: The smallest number of insects (or amount of injury) that will cause yield losses equal to the cost of insect management.
4. *Economic threshold:* The pest density at which management action should be taken to prevent an increasing population of pests from reaching the economic injury level.
5. *Natural enemy*: Predator, parasitoid, pathogen, or competitor for the same resource.
6. *Parasitoid*: An organism that, during its development, lives in or on the body of a host individual (in this case a pest), eventually killing the pest.
7. *Pesticide*: A substance used to destroy or prevent insects or other organisms harmful to cultivated plants. Includes, among others, insecticides, fungicides, and herbicides. It includes chemical pesticides and biological pesticides.
8. *Pesticide resistance*: The decreased susceptibility of a pest to a pesticide that was previously effective at managing the pest. Pest species evolve resistance to pesticides via natural selection: after a pesticide is applied, the individuals with the most resistance survive and pass on their resistance to their offspring.
9. *pH*: Soil pH is a measure of the acidity or basicity of a soil.
10. *Pheremone:* a chemical substance produced and released into the environment by animal (including insects), that affects the behavior or physiology of others of its species. Pheromone traps, for example, could release pheromones that attract male or female insects.
11. *Predators*: An insect, organism, or other creature that preys on pests.
12. *Semiochemical*: Pheromones or other chemicals that convey a signal from one organism to another in order to modify the behaviour of the recipient organism.
13. *Trap crop*: A crop planted to attract insect pests away from another crop. Trap crops are normally the pest’s preferred host and food source. They have little economic value to the farmer so, after the pest has laid eggs on the trap crop, the eggs or larvae or the infested trap crop can be destroyed.

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