

# Type: Backgrounder

Date: May 2018

Backgrounder: Fall armyworm

1. **Introduction**

The Fall armyworm, which has the scientific name of *Spodoptera frugiperda*, is a major pest of staple crops. The larvae (caterpillars) prefer feeding on young maize plants, but have also been reported to feed on a variety of other crops, including millet, sorghum, rice, wheat, sugar cane, and vegetables.

The pest originates in the tropical and sub-tropical regions of North and South America. Fall armyworm breeds and multiplies all year round, so all life stages are present at all times. The ideal climatic conditions in tropical Africa and the abundance of suitable host plants enable Fall armyworm to have several generations per year.

If pest populations are high and farmers do not take control measures, Fall armyworm can cause significant damage to maize crops. For example, larger caterpillars can destroy seedlings and young plants by cutting the stem at the base. Larvae that feed on grain make the plant more susceptible to fungal attack and aflatoxin contamination. And destruction of the silk (*see diagram below*) results in reduced pollination and reduced formation of grain.

Fall armyworm was first reported in Africa in 2016. Because the adult moth can fly up to 100 km per night, it has spread rapidly. As of December 2017, it had been reported in 38 African countries, including some island nations.

Fall armyworm is actually a caterpillar rather than a worm, and the adult stage of the pest is a moth. The caterpillar eats maize leaves, attacks the growing point (the top) of the plant, and may also burrow into the cobs in older maize crops. The older, bigger caterpillars cause about 3/4 of the total damage to the crop.

There are a number of species of armyworms in Africa, including the African armyworm, but the “Fall” type causes the most widespread damage. This is because, once it first enters an area, it is permanently present there. Unlike the African armyworm, it does not migrate en masse to other areas.

For further information: See documents 1, 3, and 10 inthe *Resource List* below.

1. **What you need to know**

***Why is this subject important to listeners?***

* Fall armyworm is causing serious damage to maize and may effect other crops—including staple crops in the grass family such as sorghum, wheat, ryegrass, and pearl millet. These are crops that farmers rely on across Africa to feed their families.
* Fall armyworm has spread to most parts of Africa. Thus, many farmers are being affected.
* The direct actions that can be taken to manage the pest are largely up to farmers who live daily with the pest in their fields.
* It appears that Fall armyworm will establish itself in Africa and become a long-term pest.
* Because it is a new pest, recommendations for managing Fall armyworm are evolving and farmers need to seek information, advice, tools, and resources on how to manage it.

***What are some key facts?***

* Fall armyworm moths lay eggs at night on the lower leaves in tight clusters of 150-200 eggs.
* Fall armyworm larvae attack plants as early as the third leaf stage.
* The caterpillars that cause the damage are most active in the early morning, and the later afternoon and evening. Therefore, this is the best time to use pesticides or other control measures.
* Fall armyworm has four life cycle stages: egg, caterpillar (larvae), pupa, and moth.
* Adult moths are strong fliers and capable of travelling long distances.
* Tropical rains can break the life cycle of Fall armyworm by washing eggs off leaves and onto the ground. They can also drown young larvae in maize whorls, causing high levels of mortality.

***What are the big challenges of Fall armyworm?***

* Because Fall Armyworm is a new pest in Africa, little is currently known about how it is adapting to local conditions. More research and more awareness is needed. National activities and an FAO-led plan that includes monitoring, surveillance, management practices, and communications is being developed.
* In the tropics, Fall armyworm has the potential to breed continuously throughout the year. This can result in bigger populations and more damage.
* Fall armyworm caterpillars can be difficult to identify because they look similar to other caterpillars, especially when young.
* Older caterpillars crawl deep into the whorl (see diagram of maize plant below) or burrow into the maize cobs, making it difficult to reach them with chemical insecticides or biopesticides.
* Small-scale farmers are often forced to use toxic pesticides to cope with the pest. This can lead to a continuing and unsustainable requirement for pesticide use. Over time, pests develop resistance to individual pesticides, forcing farmers to use more toxic products or increase the dosage. Some of these pesticides are older chemicals that are no longer approved in Europe or North America. They represent risks to the environment and could have a significant impact on local human health—and on trade because of pesticide residues in food.
* Pesticides are costly, and farmers may spend more buying pesticides than the value of the harvest that would be lost to Fall armyworm.
* There are reports that Fall armyworm has developed resistance to some chemical pesticides in the countries where it originates.

***Is there misinformation about this subject that I should cover?***

* Farmers can mistake Fall armyworm in the field for the African armyworm, known as *Spodoptera exempta*, or other pests such as African bollworm, tomato moth caterpillar, and maize stem borer.
* There are two strains of Fall armyworm: the “maize strain” and the “rice strain.” Both strains are present in Africa and both have been reported to attack a variety of crops—for example, the maize strain attacks rice, and the rice strain attacks maize.
* A number of different caterpillars attack maize plants. To identify Fall armyworm, look for an upside down “Y” on the caterpillar’s head and four dots on the second to last body segment. (See photos 5 and 6 in the linked document.)

***Gender aspects of managing Fall armyworm***

* Women are responsible for performing most farming tasks, including applying pesticides. With the increased demand for pesticides to protect crops from Fall armyworm, this will mean that women will be more exposed to pesticides. Women, like men, can transfer pesticide residues to children and entire households.

***Predicted impact of climate change on managing Fall armyworm***

* Fall armyworm is a tropical species adapted to the warmer parts of South America. The ideal temperature for caterpillar development is reported to be 28°C. Therefore, in the tropics, there is a potential for continuous breeding, resulting in four to six generations per year. Whether this will occur in Africa and what the impact of the changing climate will be on Fall armyworm is as yet unknown.

For further information: See document 1 inthe *Resource List* below.

1. **The science of Fall armyworm**
2. ***Identifying the Fall armyworm***

The Fall armyworm’s life cycle moves from egg to caterpillar (larva) to pupa to moth. (See photos below or click on the link in the email.)

***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. (See photos 1 and 2 in the linked document.)

***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. (See photos 3-7 in the linked document.)

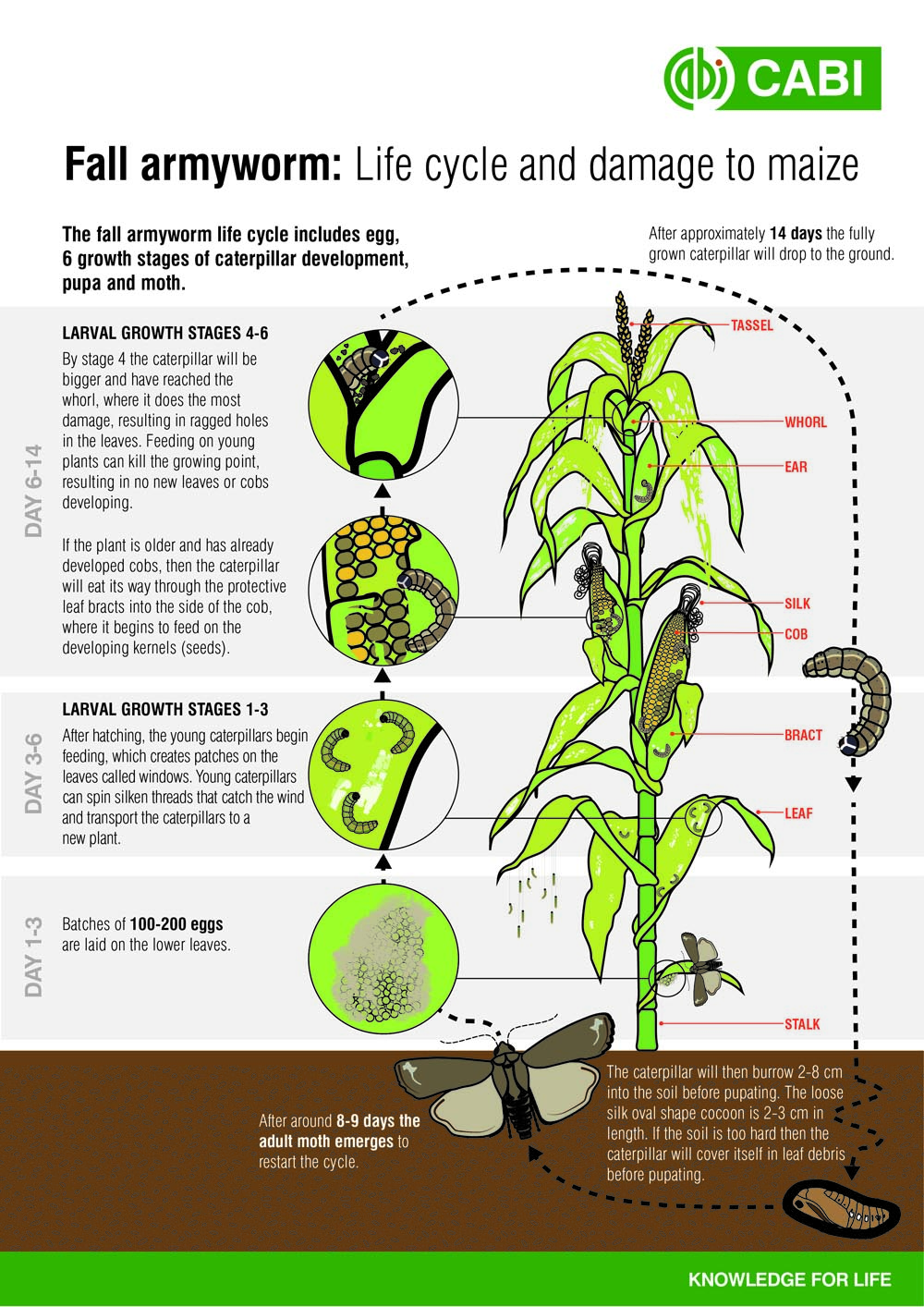
***Pupa***

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. (See photo 8 in the linked document.)

***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. (See photo 9 in the linked document.)

For further information: See documents 4 and 8 inthe *Resource List* below.



1. ***Differentiating Fall armyworm from other armyworms***

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)?
* 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.

For further information: See document 8 in the *Resource List* below.

1. ***Symptoms of Fall armyworm feeding and damage***

Young Fall armyworms start by eating plant leaves, causing a symptom sometimes referred to as “window paning.”\* Then they move to the growing points of the plant and begin to make holes in the leaves, eating from the edges of the leaves inward. During the day, small caterpillars hide in the joints between the leaves and the stem and whorl of the maize plant (see diagram). At night, they move out to feed on leaves. They may also cut the stems of young plants.

As they develop, the larvae move permanently into the whorl (see photo 13 in the linked document). This means that it is difficult to detect early infestations. On young maize plants, damage to the whorl can kill the growing point, which prevents any cobs from forming.

Feeding can cause the whorl and upper leaves to be a mass of holes, ragged edges, and excrement. With older larvae, badly infested fields may look as if a severe hailstorm has hit them.

In severe infestations, maize is completely stripped of leaves. Deep feeding in the leaf whorl can also destroy developing tassels. (See photos 14 and 16 in the linked document.)

Maize plants can recover from some leaf feeding, particularly when they are young, as long as the caterpillars do not attack the growing point of the plant.

When the plant is large, the Fall armyworm can enter the maize cob directly. The caterpillars usually burrow into the side of the cob, causing damage to grains that can lead to rot (see photo 15 in the linked document).

Fall armyworm infestation causes stunting and destruction of developing tassels and kernels, which reduces grain quality and yield (see photo 16 in the linked document).

For further information: See document 4 in the *Resource List* below.

1. **How Fall armyworm spreads**

Adult moths can fly for long distances, hundreds of kilometres with the wind. This is often how they first enter a new area. Also, the large number of eggs they lay enables the pest to quickly establish itself in a new area.

Moving infested plant materials also spreads Fall armyworm. For example, in Kenya, transporting green maize for roasting is a popular business. If this maize is infested, it contributes to the spread of the pest.

The expansion of maize monoculture across Africa may also help the pest to spread, and contribute to it affecting all farmers, both large-scale and small-scale.

The Fall armyworm prefers to feed on maize. But several factors create conditions for pest populations to quickly rise:

* the presence of other host plants where the pest can breed in the absence of maize,
* two cropping seasons in some parts of Africa,
* irrigated maize crops in some areas, and
* the presence of maize at different growth stages in the same area.

For further information: See documents 1 and 10 inthe *Resource List* below.

1. **Advice for farmers**
2. **Monitoring**

*Farmers should take actions to control the Fall armyworm only when monitoring efforts show a need for control measures.*

Starting one week after maize germinates, farmers should monitor their fields for the presence of the pest or symptoms of feeding. They should enter their fields twice a week for monitoring efforts.

**Look for:**

* Cream-coloured or grey egg masses on the surfaces of lower leaves, covered in a felt-like layer of grey-pink scales.
* Light green to dark brown larvae with three thin, yellowish-white stripes down the back and a distinct white inverted "Y" on the head.
* Larvae covered with fresh, coarse, clumped, yellowish-brown frass (excrement) inside the leaf whorl.
* Patches of skeletonized leaves\* or small “window panes.” Leaves are “skeletonized” where young caterpillars have chewed on one side of the leaf, and created large ragged and elongated holes in the leaves that emerge from the whorl. (See photo 12 in the linked document.)

Monitor damage on 10 consecutive plants in 10 randomly selected sites, for a total of 100 plants. If farmers planted plots at different times, with different varieties, or with different conditions (intercropping, different fertilization, etc.), they should monitor each plot separately. Count only those plants that are currently infested. Keep track of the number of infested plants and mark them by, for example, using a knife to cut the two lower leaves of the plant in half, or tying a coloured ribbon or coloured plastic bag to infested plants.

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.

Whenever possible, check with your local extension agent to confirm that these thresholds for using control measures are correct for your location and your crop.

For further information: See documents 9 and 10 in the *Resource List* below.

1. **Prevention and management**

There are a number of ways to try to manage Fall armyworm in maize and other crops, but because Fall armyworm is a new pest in Africa, none of them is guaranteed to be effective. There is ongoing research to identify the most effective solutions.

At the time of writing this document, the approaches listed below were believed to be the most effective.

Keep in mind that recommendations may vary between countries. For more precise recommendations on what might work best in your area, talk to your extension agent and other national experts.

***Cultural and manual practices***

* *Intercrop and rotate crops*. To reduce crop damage, rotate or intercrop with non-grass species such as cassava—or with plants (for example, some varieties of maize) that are known to repel or confuse female moths and stop them from laying eggs on maize plants.
* *Habitat management using a push-pull strategy*. This involves intercropping maize with a "push" plant that repels Fall armyworm from the field—for example, silverleaf desmodium—and planting a crop along the field boundary that attracts or "pulls" Fall armyworm away from the maize, for example, Bracharia or Napier grass.
* *Handpick* and destroy egg masses and larvae, or collect and drop larvae in hot water. (Killing one caterpillar prevents the appearance of more than 1,500-2,000 new caterpillars within less than four weeks. Destroying one egg mass prevents immediate crop damage and the appearance of more than 150,000 new caterpillars in 4-5 weeks’ time.)
* *Use good quality seeds* to increase plant vigour and potentially reduce damage.
* *Eliminate grassy weeds* in fields and nearby as they provide shelter and food for the pest.
* *Avoid late planting and staggered planting*. Plant all maize fields at the same time. Fields planted late will experience more damage.
* *Put a handful of sand* (mixed with lime or ash), or sawdust, soil, soap solutions, or grit in the whorl of attacked plants to kill bigger caterpillars.
* *Use balanced fertilization* to boost plant vigour. In maize, the recommended fertilization rate is 200 kg of NPK at 15:15:15 per ha—but this varies depending on the location.
* *Remove and destroy all crop residues*.
* *Do not move infested plant materials* to areas where the pest has not been reported.

***Biopesticides***

* Biological pesticides, including Bt (*Bacillus thuringiensis*), are an option in some African countries, though they are not always available or affordable for small-scale farmers. In some countries, governments may provide subsidies or fund spraying programs. If available, apply 1 sachet of Bt product per 15-litre knapsack twice a week at three-week intervals.
* Neem-based products.

***Chemical control***

As indicated in the section on monitoring, carefully monitor your maize to check if there is enough damage to use control measures.

If you decide to use insecticides, rotate insecticides with different modes of action. This will help stop the pest from developing resistance to individual insecticides or groups of insecticides. In the list of insecticides below, that would mean rotating products with different IRAC (Insecticide Resistance Action Committee) codes (the codes are in the brackets).

For example, in one cycle, you could spray Alpha-cypermethrin (group 3A); in the following cycle, you could change to Diazinon (group 1B), an insecticide with a different mode of action.

The following is a list of active ingredients found in products that might be effective against Fall armyworm. Contact national authorities to check which of these ingredients are in products that are available and registered for use in your country, and are recommended for use against Fall armyworm.

* *Alpha-cypermethrin* (Pyrethroids, group 3A)
* *Bifenthrin* (Pyrethroids, group 3A)
* Chlorantraniliprole (Diamides, group 28)
* *Diazinon* (Organophosphates, group 1B)
* *Diflubenzuron* (Benzoylureas, group 15)
* *Emamectin benzoate* (Avermectins, Milbemycins, group 6)
* *Flubendiamide* (Diamides, group 28)
* *Gamma cyhalothrin* (Pyrethroids, group 3A)
* *Indoxacarb* (Oxadiazines, group 22A)
* *Lambda-cyhalothrin* (Pyrethroids, group 3A)
* *Lufenuron* (Benzoylureas, group 15)
* *Permethrin* - granular (Pyrethroids, group 3A)
* *Spinetoram* (Spinosyns, group 5)
* *Spinosad* (Spinosyns, group 5)
* *Trichlorfon* (Organophosphates, Group 1B)

Spray early in the morning or in the late afternoon or night. This is when the caterpillars are most active. Pesticides must be applied at the correct dose. Try to ensure that the spray gets into the whorl, as this is where the older and most destructive caterpillars are. Avoid spraying under adverse environmental conditions such as high winds or when it is raining, as this will reduce the effectiveness of the chemicals.

Farmers can safely apply Pounce (permethrin) granules with handheld applicators as long as they follow label protections, including using non-absorbent gloves. This product works well against even medium-sized to large Fall armyworm larvae feeding within whorls, because farmers can place them directly into the protected part of the plant where the larvae feed.

Management is most effective when all farmers in an area use control measures. Fields that are not controlled act as breeding grounds for the insect and a source of re-infestation.

Farmers need to know that *broad-spectrum pesticides*\* may also kill the natural enemies that control Fall armyworm. In the above list, broad-spectrum pesticides are in italics.

One difficulty of using insecticides to manage Fall armyworm is the caterpillar’s tendency to hide within the whorls and reproductive parts of the host plant, where it is difficult to reach them with insecticide sprays. This is why, when spraying, farmers should direct the nozzle towards the whorl/funnel.

**Caution:** Pesticides are poisonous. When using a pesticide, always wear protective clothing (including non-absorbent gloves and a mask) and follow the instructions on the product label, including recommended dosage, timing of application, and pre-harvest interval. It’s also important to avoid spraying pesticides near bodies of water, and to avoid spraying at times (such as early morning) when bees are actively foraging.

For further information: See documents 1, 3, 4, 9, and 10 in the *Resource List* below.

You can find the photos mentioned in this document at the following link (300 KB): <http://scripts.farmradio.fm/wp-content/uploads/FAW-photos-FINALENGLISH.pdf>

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

1. Abrahams, P., Bateman, M., Beale, T., Clottey, V., Cock, M., Colmenarez, Y., Corniani, N., Day, R., Early, R., Godwin, J., Gomez, J., Gonzalez Moreno, P., Murphy, S.T., Oppong-Mensah, B., Phiri, N., Pratt, C., Silvestri, S., Witt, D., 2017. *Fall Armyworm: Impacts and Implications for Africa. Evidence Note (2), September 2017*. CABI.

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1. Armyworm Network. *African armyworm in the press*. <http://www.lancaster.ac.uk/armyworm/press/>
2. Armyworm Network. *What is the fall armyworm?* <http://www.lancaster.ac.uk/armyworm/what-is-fall-armyworm/>
3. CABI Invasive Species Compendium, undated. *Farm armyworm* (*Spodoptera frugiperda*). Datasheet. <http://www.cabi.org/isc/datasheet/29810>
4. CABI Invasives Spodoptera frugiperda curated Twitter list.<https://twitter.com/CABI_Invasives/timelines/831799538025373696>
5. EPPO Global Database. *Photos of Spodoptera frugiperda*. <https://gd.eppo.int/taxon/LAPHFR/photos>
6. Gardner, Elliot, May 31, 2017. *Fear the fall: the armyworm that threatens food growers everywhere*. <http://www.foodprocessing-technology.com/features/featurefear-the-fall-the-armyworm-that-threatens-food-growers-everywhere-5829941/>
7. Plantwise: *How to identify Fall armyworm*. <http://www.plantwise.org/FullTextPDF/2017/20177800461.pdf> (3.98 MB)
8. *Plantwise Pest Management Decision Guide: Green List*: <http://networking.afaas-africa.org/sites/default/files/CABI%20FAW%20Booklet%20%282%29_0.pdf> (1.98 MB)
9. Prasanna, B.M., Huesing, J.E., Eddy, R., Peschke, V.M., (eds.), 2018. *Fall Armyworm in Africa: A Guide for Integrated Pest Management*, First Edition. Mexico, CDMX: CIMMYT. <https://reliefweb.int/sites/reliefweb.int/files/resources/FallArmyworm_IPM_Guide_forAfrica.pdf> (3.68 MB)
10. Slowfood.com, 2017. *Fall armyworm: too late to avert disaster?* <https://www.slowfood.com/fall-armyworm/>

***Key definitions***

1. Biopesticides: A type of pesticide that is based on micro-organisms or natural products, for example, the bacteria *Bacillus thuringiensis* (Bt), the fungus *Beauveria bassiana*, or the neem tree.
2. Broad-spectrum insecticides: Insecticides that kill or manage a wide variety of organisms. Opposed to narrow-spectrum insecticides that are designed to kill or manage one or only a few organisms.
3. Leaf whorl: An arrangement of sepals, petals, leaves, stipules, or branches that radiate from a single point and surround or wrap around the stem. (See diagram.)
4. Natural enemies: Natural enemies of insect pests, sometimes known as biological control agents, include predators, parasitoids, and pathogens.
5. Parasitoids: An insect (often a wasp) that completes its larval development within the body of another insect, eventually killing it.
6. Pathogens: Micro-organisms that cause diseases.
7. Predators: Insects or other creatures that eat the pest.
8. Skeletonized leaves: Leaves with only veins remaining, and no soft tissue.
9. Window paning: Semi-transparent patches on the leaf surface, a symptom of feeding on the underside of leaves where only the waxy layer on the upper surface of the leaf remains.

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