# Fall Armyworm:

## Potential biopesticides for the management of fall armyworm (*Spodoptera frugiperda*) in Africa

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# Key messages

From the biopesticides reviewed as part of this study, 23 are selected for follow-up, 10 of which should be prioritized for immediate action. Recommended next steps include:

For biopesticides that are effective against fall armyworm (FAW), have low toxicity, and are already registered

- Gather further information to assess local availability and affordability
- Increase availability through local production of biopesticides
- Provide information on biopesticides to local agricultural advisors to enable them to support farmers

For other biopesticides not yet registered or not yet proven to be effective against FAW

- On a country-by-country basis, prioritize the biopesticide active ingredients to be evaluated in laboratory bioassays and field trials
- Where tests are already carried out, ensure that information on the results is shared with other countries
- Carry out risk assessments to establish whether biopesticides of known toxicity can be safely used in FAW-affected countries.
- Regulators of each country's registration process consider options to make it simpler to register or import low toxicity biopesticides for FAW
- Ensure rapid availability following registration. This can be achieved through the importation and / or local production of biopesticides
- Supply systems should be developed in collaboration with the private-sector to ensure biopesticides reach farmers as soon as they become available

# Purpose

This brief summarises a recent study which identified potential biopesticides for the management of FAW in Africa. Findings from the study can be used by the relevant plant health stakeholders in African countries affected by FAW to select the most promising biopesticides for further investigation, future testing and possible registration and use by smallholder farmers.

# What is FAW and why is it important?

- FAW, scientific name *Spodoptera frugiperda*, is a moth whose caterpillars can potentially feed on 100 different species of plants. It is known as a serious pest of maize, rice, sorghum, teff, sugar cane and a wide range of other crops including peanuts and soybean as well as non-food crops such as cotton. In maize, the FAW caterpillars feed on the developing leaves and then the grains, damaging the plant and reducing the yield.
- FAW was previously found only in the Americas, but in 2016 it appeared in West Africa. It is now found in over 40 countries in tropical and southern Africa. It has also spread to Madagascar, and was recently reported from India.
- In Africa, FAW presents a serious risk to food security and its impact on maize alone could devastate the livelihoods of tens of millions of affected farmers.
- It has been estimated that FAW has the potential to cause maize yield losses of at least 20% in Africa's maize-producing countries (See Day et al. 2017. https://doi.org/10.1564/v28_oct_02).
- In order to protect their food supplies, affected countries in Africa are putting in place large-scale emergency measures to control FAW. Many of these measures focus on the widespread distribution and use of pesticides, some of which are harmful and highly toxic. This puts many smallholder farmers at risk, as they may be encouraged to use toxic products that they are unfamiliar with and for which they may lack the personal protective equipment needed to prepare and apply them safely.

# What are biopesticides?

Biopesticides are based on naturally occurring substances or organisms that kill pests. These include:

- Biochemical biopesticides – plant extracts and other naturally occurring chemicals such as insect pheromones, extracts from microbes, and inorganic compounds and minerals. Synthetic copies of these natural chemicals are also used.
- Microbial biopesticides – bacteria, fungi, yeasts, algae and viruses that cause disease in the pest insects
- Microbial biopesticides – insect predators and parasitoids such as wasps and nematodes

Each different biopesticide organism or substance is called an active ingredient. Each active ingredients may be found in several products with different brand names.

# Controlling FAW with biopesticides

- FAW can be controlled using an integrated approach combining a variety of agricultural practices together with the use of appropriate biopesticides.
- Biopesticides are generally considered to present safer, lower risk options for controlling FAW than conventional chemical pesticides, although some have high toxicity and should be avoided unless the risks can be safely managed.
- Biopesticide products to control FAW are commercially available in the Americas and are regularly used by farmers in these countries. Conversely, few biopesticide products are registered for use in African countries and most of the ones registered are not yet registered for FAW, not widely available or not affordable, particularly for smallholder farmers.

# Identifying the most promising biopesticides

- In order to help control FAW in Africa and reduce the use of harmful pesticides, a study was carried out to identify biopesticides with the greatest potential to control FAW in African farms.
- The study assessed biopesticide active ingredients from over 1,000 products registered in 30 countries globally.
- To help narrow down the selection to those most appropriate for African smallholder farmers, each biopesticide was evaluated against the following six key criteria:

Is the biopesticide:

| | |
|---|---|
| ✓ **Effective** | It is proven to be effective against FAW or other closely related moths. |
| ✓ **Safe** | It is safe for use by farmers and for the environment. This is determined using information from national and international databases which list all known human and environmental hazards associated with all chemicals and biopesticides. |
| ✓ **Sustainable** | It is unlikely to cause harm to insects that are beneficial to farmers (e.g. pollinators) or cause FAW to develop resistance, and it will not become a pest itself. |
| ✓ **Practical** | It is easy for smallholder farmers to apply and easy to store. |
| ✓ **Available** | It is registered for FAW in the African countries covered in this study and available in-country. Only products registered for FAW can be legally sold and used for FAW. |
| ✓ **Economic** | It is affordable for smallholder farmers and costs of using it do not outweigh the benefits. |

# Potentially useful biopesticides for control of FAW

Of the 50 biopesticide active ingredients assessed, 23 were identified as potentially useful for the control of FAW in Africa and were recommended for follow-up investigation. These promising biopesticides are shown in the table below. Based on the information assessed:

- Twelve biopesticide active ingredients (those in the first table column below) are already reported as being effective against FAW and most are registered in at least some African countries. However, there are safety concerns regarding four of these, which need to be assessed in a national context. The remaining eight AI should be prioritized for immediate field testing in Africa.
- The three biopesticide active ingredients in the second column have been tested on FAW in laboratory tests and look promising, but still require testing to confirm if they are effective against FAW in field conditions in Africa and there are safety concerns regarding one of them.
- The eight biopesticide active ingredients in the third column are effective against insects related to FAW, but still need to be tested on FAW, or there are concerns about sustainability that need to be evaluated. These tests will take time and therefore these biopesticides are less of a priority.

| | **Reported effective against FAW in field trials in native range** | **Reported effective against FAW in laboratory bioassays** | **Reported effective against related pests** |
|---|---|---|---|
| **Registered outside sub-Saharan Africa** | • *Spodoptera frugiperda* nucleopolyhedrovirus (NPV) | • *Dysphania ambrosioides*[2] | • Garlic oil<br>• Allyl isothiocyanate[2]<br>• Sucrose octanoate |
| **Registered within sub-Saharan Africa** | • Azadirachtin (neem products)<br>• *Bacillus thuringiensis* products<br>• Lufenuron[2]<br>• Methoxyfenozide<br>• Oxymatrine<br>• Pyrethrins[2]<br>• Sex pheromones[1]<br>• Silicon dioxide<br>• Spinetoram[2]<br>• Spinosad[2]<br>• *Trichogramma* spp.[1] | • *Beauveria bassiana*<br>• Matrine | • Capsaicin<br>• Kaolin clay<br>• Maltodextrin<br>• *Metarhizium anisopliae*<br>• Orange oil |

[1] In many countries, sex pheromones and macrobials do not need to be registered

[2] There are concerns regarding the toxicity of these AI. They require careful risk assessment before prioritizing for evaluation in Africa

# Recommendations

## Immediate and short-term activities

For the eight priority biopesticides listed in the first column of the table with low toxicity, the following is recommended:

**Where these biopesticide active ingredients are already registered:**

- **Assess availability and affordability** – Each country should assess local availability and affordability of the biopesticide AIs. This can be done through surveys with retailers and farmers.
- **Increase local production** – Where availability is limited but demand is high, the facilitation of private-sector engagement is required to encourage local production of biopesticides.
- **Provide information** – Local agricultural advisors should be provided with information on biopesticide products that become available so that they can include them in their management advice to farmers. CABI's Plantwise (www.plantwise.org) programme will support knowledge provision and sharing.

**Where these biopesticide active ingredients are not yet registered:**

- **Laboratory and field testing** – Each country should prioritize active ingredients for future testing and carry out laboratory bioassays and field trials. Field trials will help to assess whether the priority biopesticide active ingredients are effective under local conditions and if they could be incorporated into smallholder farmer integrated pest management schemes.
- **Registration** – For biopesticides proven effective through field trials, the next step will be to carry out risk assessments required for registration (or issuing import permits for macrobials).
- **Importation and production** – In order to ensure rapid availability following registration, the importation and / or local production of biopesticides through private-sector engagement should be assessed and developed. Also, supply systems should be developed in collaboration with the private-sector to ensure biopesticides reach farmers as soon as they become available.
- **Information sharing** – To benefit from each other's experiences, the results of the trials carried out should be shared between countries and actors. This will help to prioritise active ingredients for testing and registration across various countries and ensure a harmonised pest management approach.

## Medium-term activities

- Carry out local risk assessments on the use of biopesticide AI that have been reported effective against FAW, but are known to have high toxicity.
- Identify other macrobials to be used for biological control. CABI's Action on Invasives programme (www.invasive-species.org) will help assess what macrobial natural enemies are available, suitable and safe for use in Africa.
- Consider changes to the registration process to promote low toxicity biopesticides for FAW management. In many countries, the process for registering biopesticides is the same as for synthetic pesticides and this can slow the registration process and increase costs. To speed up this process for biopesticides, data requirements for registration may be reduced and registration fees can be lowered.

# Glossary

| Name | Type of biopesticide | What is it? |
|---|---|---|
| Allyl isothiocyanate | Biochemical | A chemical found in the essential oil of mustard. |
| Azadirachtin | Biochemical | Extract of neem tree *Azadirachta indica*. Prevents normal insect growth and development. |
| *Bacillus thuringiensis* (Bt) | Microbial | One of the most commonly registered biopesticides. Bt is a bacterium naturally found in soils. Once ingested by the caterpillar. Bt release toxic chemicals that kill the insects. Several different strains are in use and will need to be evaluated separately. |
| *Beauveria bassiana* | Microbial | A fungus which occurs naturally in soil and can cause disease in insects. |
| Capsaicin | Biochemical | Extract of chilli peppers containing the chemical oleoresin. Capsaicin acts as a repellent and may also cause nerve and cell damage in insects. |
| *Dysphania ambrosioides* | Biochemical | Extracts of the plant *Dysphania ambrosioides* (American wormseed) containing terpenoid chemicals which soften insect cuticle and disrupt respiration. |
| Garlic oil | Biochemical | Extract from garlic, which acts as an insect repellent. |
| Kaolin clay | Biochemical | A white mineral clay which when applied to crops, controls for damage from a wide range of insects, mites and diseases. |
| Lufenuron | Biochemical | A natural chemical that affects insect growth and development but the product used is synthesised. |
| Matrine & Oxymatrine | Biochemical | A chemical found in plants of the genus *Sophora* (related to peas). |
| Maltodextrin | Biochemical | A glucose compound. When sprayed on insects the solution dries, blocking up their spiracles and preventing breathing. |
| *Metarhizium anisopliae* | Microbial | A fungus which occurs naturally in soil and can cause disease in insects. |
| Methoxyfenozide | Biochemical | Synthetic chemical which affects insect growth and development. |
| Oil of orange & orange seed extract | Biochemical | Extracts of orange containing D-limonene and linalool. Limonene and linalool disrupt the insect nervous system causing paralysis. |
| Pyrethrins | Biochemical | Derived from dried, powdered flowers of *Chrysanthemum cinerariaefolium*. Pyrethrins cause paralysis and death in insects. |
| Sex pheromones | Biochemical | Natural chemicals released by insects to attract a mate. Can also be used for monitoring pest numbers and baiting traps. |
| Silicon dioxide (diatomaceous earth) | Biochemical | Naturally occurring soft rock made from fossilised micro-organisms and containing silicon dioxide. It has many applications in agriculture, including as a pesticide. |
| Spinetoram and Spinosad | Biochemical | Compounds derived from the fermentation of the soil bacteria, *Saccharopolyspora spinosa*. |
| *Spodoptera frugiperda* NPV | Microbial | A type of insect virus which infects and kills FAW. |
| Sucrose octanoate | Biochemical | Synthetic sugar ester. |
| *Trichogramma* spp. | Macrobial | *Trichogramma* spp. are very small wasps that parasitize eggs of FAW and other moths. |

The study was conducted by CABI as part of its global Action on Invasives programme combatting the threat and impact of invasive species. Leveraging the CABI-led Plantwise programme, we further optimise the exchange of information among stakeholders in countries affected by FAW.

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To find out more contact either of the following:

**Roger Day**, Programme Executive, Action on Invasives
**T:** +44 (0)1491829444
**E:** r.day@cabi.org

**Matthew Cock**, Chief Scientist
**T:** +44 (0)1491829037
**E:** m.cock@cabi.org

**www.cabi.org**

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