Food and Agriculture Organization of the United Nations

Fall armyworm management

Farmer field school experiences in Africa


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Food and Agriculture Organization of the United Nations
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Contents

Acronyms
and abbreviations

FAO	Food and Agriculture Organization of the United Nations
FAW	Fall armyworm
FFS	Farmer field school
IPM	Integrated pest management
SNNP	Southern Nations, Nationalities, and Peoples' region
ToF	Training of facilitators

1. Introduction

Fall armyworm (FAW), *Spodoptera frugiperda*, is an insect native to tropical and subtropical regions of the Americas. FAW larvae can feed on more than 80 plant species, including maize, rice, sorghum, millet, sugarcane, vegetable crops and cotton. Several generations can occur in a year, and the moth can fly up to 100 km per night with support from the wind. FAW is a damaging pest that will continue to spread due to its biological characteristics and high volumes of trade among African countries. Farmers need substantial support to sustainably manage this new pest in their cropping systems through integrated pest management (IPM) farming options.

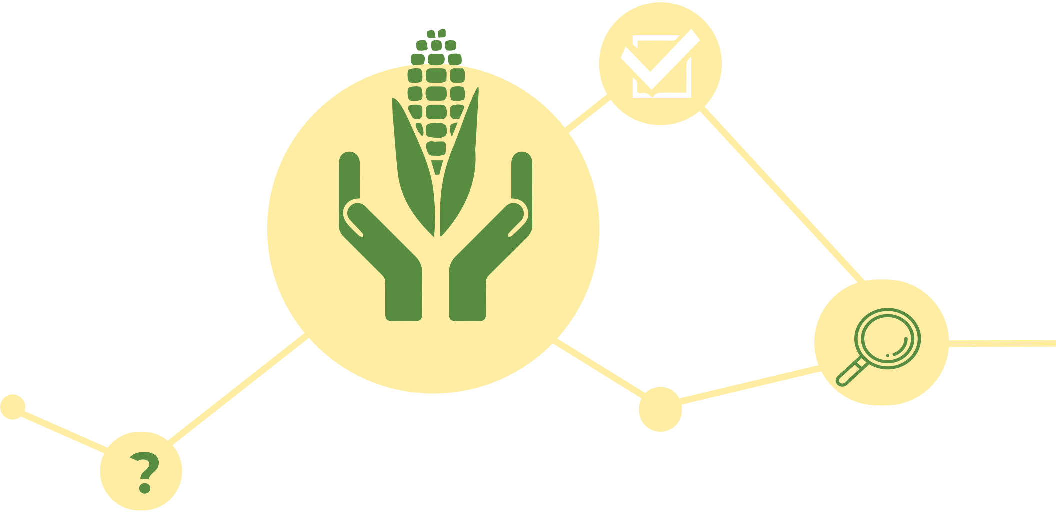
Farmer field schools (FFS) provide an interactive and participatory learning-by-doing approach that puts farmers at the forefront through hands-on and discovery-based learning. Groups of about 25–30 participants with common interests learn about improved agricultural practices through a season-long programme of selected trial options. A trained facilitator guides weekly learning sessions and takes participants through field observations and critical analyses, focusing on selected, real-life enterprises. FFS builds on local knowledge systems while testing and validating innovative scientific concepts developed in other locations through experiments conducted on study plots, to compare local and improved practices. Each week, participants observe and monitor all elements of the agro-ecosystem on the farm or in the field, and learn how to make management decisions appropriate to the challenges they face.

FFS group members summarize their findings, discuss the situation observed, and present and debate possible management solutions. At the end of the season-long learning period, the FFS groups analyse all the trials based on cost, availability, production potential and applicability among other factors, and decide on the best option. Dissemination of information to the broader community on experiences from the FFS occurs through field days and exchange visits. Through FFS, farmers improve their analytical, decision-making and communication skills. The FAO Global FFS Platform[1] provides general information as well as information concerning technical areas, including FAW.

[1] http://www.fao.org/farmer-field-schools/home/en/

2.

The FAO response to fall armyworm



2. The FAO response to fall armyworm

Since the FAW outbreak began in 2016, the the Food and Agriculture Organization of the United Nations (FAO) has taken multiple actions to strengthen countries' capacity to respond to FAW through Technical Cooperation Programme projects and other funded initiatives.

Several projects are aimed at reducing the infestation and spread of FAW, through implementation of a FAW Monitoring and Early Warning System (FAMEWS[2]), production and dissemination of communication materials and capacity development through FFS interventions.

In 2018, FAO developed an FFS guide on integrated management of FAW on maize[3]. In December 2019, FAO launched the Global Action for FAW Control[4] as a response to the international threat that FAW is posing for food security and the livelihoods of millions of smallholder farmers.

[2] http://www.fao.org/fall-armyworm/monitoring-tools/famews-mobile-app/en/
[3] http://www.fao.org/publications/card/en/c/I8665EN
[4] http://www.fao.org/fall-armyworm/global-action/en/

3. Highlights and successes

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3. Highlights and successes

Through FAW-related FFS programmes in Africa, several options for mechanical and biological control and management of FAW have been trialled and evaluated by farmers, with many showing promising results.

HIGHLIGHTS

1. Farmers developed FAW monitoring and recognition skills key for successful FAW management.
2. FAW damage to maize was significantly reduced through monitoring and group-based decisions whether to mechanically control or apply botanicals.
3. Use of botanicals for FAW control has become a cultural practice.
4. Maize production and productivity improved with the introduction of FAW control options.
5. Teamwork spirit was developed in FFS groups, creating a sense of responsibility among participants.
6. Male and female farmers were empowered, through the FFS approach of soft skills development, to express their thoughts and opinions in public with confidence.
7. FFS are shown to be effective at introducing behavioural change among participants by changing perceptions and beliefs that pesticide application is the only method to control FAW or other invasive pests effectively. FFS participants have instead learned the ecology and biology of FAW and seek alternative, environmentally friendly methods to manage this new pest sustainably in their cropping systems.

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49

49 FFS established in Amhara, Oromia and SNNP regions.

One trained facilitator per FFS.

Various FAW management and control options tested.

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21

21 FFS in two counties.

Various FAW management and control options tested.

Training of facilitators (ToF) undertaken for FFS as well as government extension staff.

ToF-developed trial options and development of season-long learning curriculum.

4.

Mechanical control

4. Mechanical control

Mechanical control options entail the management and control of pests using physical means such as hand-picking of egg masses and larvae, crushing or creating physical barriers. It includes weeding and altering the micro-climate (e.g. temperature) to control pests.

Mechanical control options for FAW include:

- regular field visits (twice weekly) to crush egg masses and larvae;
- pouring ash, sand, sawdust or dirt into whorls to dry out and control larvae;
- pouring water in the maize whorl to drown larvae.
- FFS farmers in Benin picked larvae to feed them to chicks for poultry production. FAW can be considered a good complementary source of protein in countries where insects are consumed.

In **Embu, Kenya,** some farmers and FFS groups focused on mechanical control through hand-picking and crushing the FAW larvae from the maize plants. A pilot project in 2018, assisting farmers with mechanical control through employed field scouts, showed that half of the 300 farmers in the pilot preferred the inexpensive method of hand-picking and continued monitoring of their crop without the support of field scouts in subsequent seasons.

In **Ethiopia**, improved farming practices, soil and weed management, use of quality seeds as well as hand-picking and application of cultural pesticides (botanicals and plant derivatives) are being used by farmers as major control methods. Farmers prepare insecticides from chilli plants and cattle urine and apply these on affected plants. Although initially less effective in killing insects, farmers are improving the insecticides' composition and effectiveness over time.

5.

Biological control

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5. Biological control

Biological control is a method of pest control using natural enemies (bio-control agents) against the target pest.

Some FAW enemies may be naturally occurring in Africa (general predators, parasitoids and some entomopathogens) and some may be introduced from other geographic regions (non-native parasitoids, predators and certain strains of entomopathogens).

Why not pesticides?

FFS test groups that used pesticides noted that the chemical is harmful to 'friendly insects' such as bees and ladybirds, which affected the pollination of crops other than maize. If not properly managed and applied, pesticides can have a serious negative impact on human health and the environment.

Earwig © Pest Guide 2019

Ground beetle © FAO 2020

Biological control **methods**

Predators

Several indigenous natural predators have been discovered in Africa. However, research efforts on conservation as well as encouragement and augmentation of these must be strengthened. Natural predators include:

- Earwigs
- Ladybird beetles
- Ground beetles
- Assassin and flower bugs
- Spiders
- Ants
- Birds and bats

Parasitoids

About 150 different parasitoid species prey on FAW in various crops. Preliminary field data in Africa demonstrate that some parasitoid species have attacked FAW eggs and larvae, but research efforts on conservation as well as encouragement and augmentation of these must be strengthened. Parasitoid species include:

- *Chelonus curvimaculatus* Cameron
- *Coccygidium luteum* (Brullé)
- *Cotesia icipe* Fernández-Triana & Fiaboe
- *Charops ater* Szépligeti
- Eusocial, solitary and other predatory wasps
- *Trichogramma pretiosum*
- *Trichogramma atopovirilia*

Trichogramma wasp
© Simon van Noort

Coccygidium luteum
© Simon van Noort

Entomopathogens

Entomopathogens are disease-causing agents such as viruses, fungi, nematodes and bacteria. Farmers grind them, strain the body parts out, mix the filtrate with water and spray it back into the whorls of FAW-infested plants. Data on entomopathogens are scant – extension and research professionals should be consulted before farmers utilize entomopathogens for FAW control. Countries may impose import regulations on non-native insects. Some may be harmful to the native ecosystem and cause damage to already existing beneficial insects. Review national regulations before considering this approach.

- Viruses
  - Nuclear Polyhedrosis Virus
  - *Spodoptera frugiperda* Multicapsid Nucleopolyhedrovirus
  - Baculoviruses
- Fungi
  - *Metarhizium anisopliae*
  - *Metarhizium rileyi*
  - *Beauveria bassiana*
  - *Aspergillus oryzae* – Based on field and laboratory trials conducted in the United Republic of Tanzania, the National Plant Protection Advisory Committee provided approval for biopesticide registration in June 2020. The biopesticide is expected to be a major boost in controlling FAW, which has plagued farmers' fields since its invasion of the United Republic of Tanzania in 2017.
- Bacteria
  - *Bacillus surigensis*
  - *Bacillus thuringiensis*
- Nematodes
- Protozoa

An FFS participant in Kenya strains a botanical mixture before spraying on affected maize plants. ©FAO/P. Mutungi

Botanicals

Botanicals are naturally occurring chemicals extracted or derived from plants with insecticidal properties. Normally, a designated quantity of the botanical is gathered, crushed and left to soak in water for a few days. The mixture is then strained to remove the botanical and remaining fibres. The solution can then be diluted with water or applied directly on the maize to act as a repellent against FAW. Some botanical options applicable for FAW management and control are:

- Neem
- Mexican sunflower (*Tithonia*)
- Persian lilac
- Pyrethrum
- Acacia
- Fish-poison bean
- Wild marigold
- Wild sage
- Hot pepper (Chilli)
- Onion
- Tobacco
- Wild sunflower
- Lemongrass

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© FAO, 2018

Traditional knowledge

Traditional knowledge includes farmers' local knowledge, observations and/or experimentation with various tactics for pest control. These locally tested control options have been reported with success across Africa, but there is little scientific evidence to support claims of the effectiveness of these controls. To have scientific backing, such options should therefore be further tested and confirmed by agricultural research institutions in collaboration with farmers under local conditions.

Traditional control options may include:

- oil, lard or fish soup to attract predatory ants or wasps to crops; these subsequently feed on the FAW larvae;
- urine from rabbits, cattle or other small ruminants as a repellent; and
- ash, which provides a hostile environment for the FAW larvae.

Ant © Pest Guide 2019

6.

Environmental control

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6. Environmental control

Habitat management is an important strategy for pest control in integrated pest management. Various categories of habitat management such as trap cropping, intercropping, natural enemy refuges such as 'beetle banks', and floral resources for parasitoids and predators have been used in applied insect ecology for many years.

In push-pull systems, farmers intercrop cereals with plants that exude pest-repellent volatiles such as *Desmodium spp.* ("push") and plant pest-attractive grass species such as *Pennisetum purpureum* Schumach, as a border around the field ("pull"). The chemicals emitted by the desmodium are unattractive to the FAW moth, which pushes them on to the napier grass where they lay their eggs. When the eggs hatch and the small larvae bore into napier grass stems, the grass produces a sticky substance like glue, which traps and kills them.

Originally developed for the control of stem borers, the push-pull method has proven to be an effective control method in the demonstration plots. It involves intercropping maize with silver leaf desmodium as the 'push' crop and napier grass as the 'pull' border crop.

7.

Home-made remedies

An FFS participant in Kenya shows a home-made remedy to other participants.

7. Home-made remedies

Home-made remedies applied in FFS groups in Kenya included the use of botanicals – tobacco, ash, oils, detergent – as well as push-pull methods as preventative and post-infestation measures. Remedies were often applied during group trial set-ups alongside chemical control methods, so as to provide a control representing the usual farmer practice.

EXAMPLE

Tobacco and Ash Method (from Manani FAW FFS, Kenya)

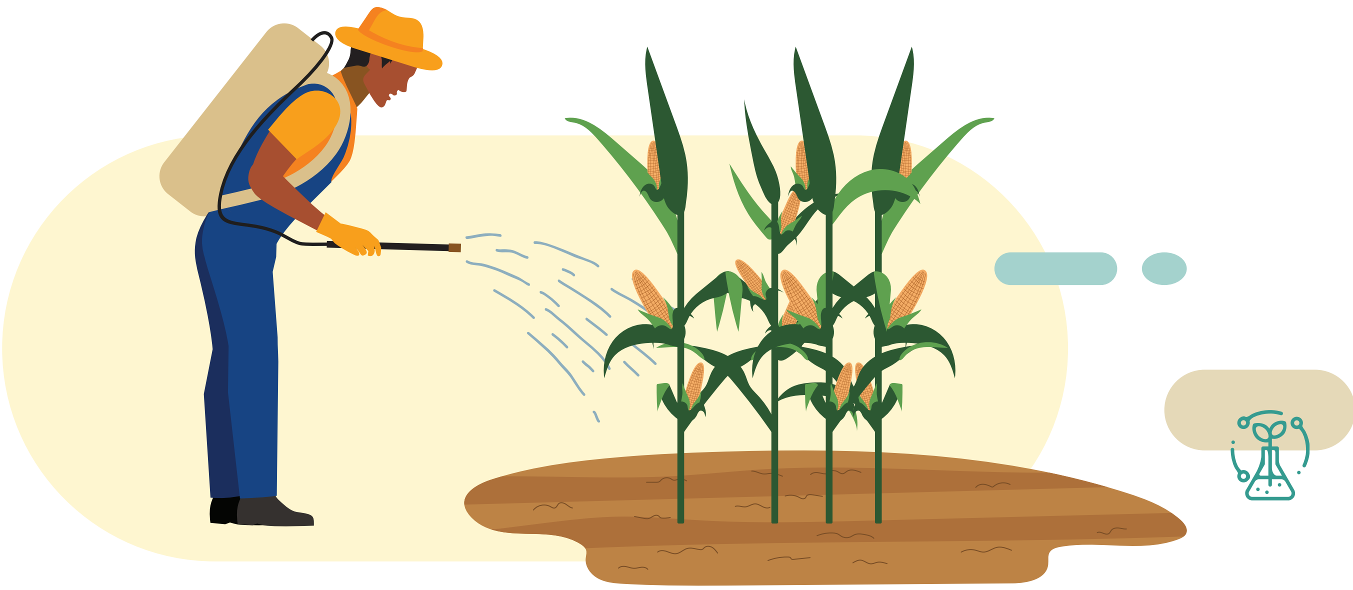
Note: Make sure to spray early in the day if your location has rainy spells. The mixture works best to kill the eggs on the leaves and will not work on the larvae.

You will need:

- 500 g wood ash;
- 4 tablespoons of tobacco;
- 22 litres of water;
- Knapsack sprayer.

Method:

- In a suitable container, combine the wood ash and tobacco in two litres of clean water.
- Cover and soak for one day.
- Measure 29 g of the soaked mixture into the knapsack sprayer and add 20 litres of water. Mix well until it combines.
- Spray on the maize plants when they are about 2 ft tall.



1. Mexican sunflower (*Tithonia*) extract (botanical pesticide)

Tithonia is a local weed/herb used to prevent FAW infestation. To make the pesticide, harvest leaves and young stems and crush them with a mortar and pestle. Add water to the crushed paste and sieve to get a clear liquid. Five litres of water are used to dilute 15 kg of concentrated Mexican sunflower paste to form a clear liquid pesticide. The extract is poisonous, killing both the worm and eggs. It has some residual effect to keep the FAW moths away. Furthermore, it supports plant growth, vigour and health. Maize crops treated with the extract in **Kenya** showed almost no signs of infestation.

Challenges with this method include correct dosage measurement for uniform application, and the paste cannot be sprayed using pumps as it blocks the sprayer nozzles. Furthermore, this is a time-consuming activity, so it may be impractical for large farms.

2. Mexican sunflower (*Tithonia*) extract mixed with chilli (botanical pesticide)

Recipe 1: Harvest 3 kg of leaves and cut into small pieces. Crush the cut leaves and place into a bucket with 10 litres of warm water. Cover tightly with a lid or polythene paper for three days. After resting, uncover, stir and cover again for four days. After resting for a total of seven days, add 10 crushed chilli peppers, stir and sieve. Add 10 more litres of water and place the total 20 litres of solution into a knapsack sprayer. The solution should be sprayed weekly.

Recipe 2: Add 20 g of dry chilli pods, or 100 g of fresh chilli pods per five litres of water dilution. The chilli fortifies the potency of the mixture so that it has a faster and more effective killing effect on FAW larvae and eggs.

Similar to results obtained from application of plain Mexican sunflower, with this mixture the maize crop showed signs of better health with almost no signs of FAW damage.

3. Sodom apple extract (botanical pesticide)

Sodom apple extract is prepared by crushing 30–40 ripe Sodom apple fruits and mixing it with 2 litres of water. Leave to soak for 24 hours, strain through a sieve, then add two teaspoons of dishwashing detergent. The mixture is diluted with water at a ratio of 1:9, then sprayed on the infested plants or as a preventative measure. The extract kills FAW and its eggs. It has a residual effect as well, keeping FAW moths away from the plants. This method showed good results in killing FAW and its eggs, and the healthy maize showed limited signs of infestation. The challenge with this method is to produce accurate dosage rates for uniform application.

4. Neem extract (botanical pesticide)

Recipe 1: Take 3 kg of green neem leaves, cut, crush and place into a bucket. Add 10 litres of warm water, cover tightly with a lid or polythene paper and allow to rest for three days. Open, stir and cover again for four more days. Uncover the mixture after the fourth day, stir and sieve. Add 10 more litres of water, place into a knapsack sprayer and spray on maize plants.

Recipe 2: Fill a 20-litre bucket with loosely chopped neem leaves. Then place the chopped neem leaves in a 50-litre bucket and fill with 25 litres of water. Place a lid on the bucket and leave it for three days to brew. Strain the mixture and add two teaspoons of oil and dishwashing detergent so that the mixture will stick to affected plants. Spray directly onto the plants without diluting the mixture.

Neem extract kills the worms and larvae and prevents reinfestation by moths. Trials on maize plants presented good results in killing FAW and its eggs, as healthy maize showed limited signs of infestation. The challenge with this method is to calculate accurate dosages for uniform/ harmonized application.

5. Fish and vegetable oils

Recipe 1: Apply 5–10 g of fish oil onto the stems of the affected maize plants.

Recipe 2: Use 30 g of selected fish or vegetable oil per four litres of water, spraying evenly at two-week intervals throughout the growing season.

Recipe 3: Apply 5–10 g of cooking fat at the base of the maize plant.

Fish and vegetable oils are applied on maize stems. For cooking fat, the solution is applied to the base of the maize plant. The ants are attracted to the smell of the oils and fats. The ants then devour the FAW and its eggs, demonstrating how ants are beneficial insects for farmers. This trial yielded promising results: damage was minimal and crop health overall was described as 'good'. It was noted that fish oil had a better effect than vegetable oil but is more expensive. While this method is safe and poses no health hazards, the application process may be tedious for larger farms and in some cases, oils were used but attracted no ants.

6. Detergent

Mix 20 g of detergent with 20 litres of water and spray on affected plants. This mixture suffocates and kills the worms. Damage to maize by FAW was minimal and the crop health was good. Improper dosages may negatively affect plant health.

7. Tobacco, ash/chilli/soil mixture

Recipe 1: Mix 2 kg of wood ash with 50 g of tobacco. Sprinkle the mixture onto the maize plants as a dust.

Recipe 2: Steep 240 ml of dry tobacco and 20–40 chopped chillies in four litres of water for approximately one hour. Soaking for longer periods produces a stronger pesticide. Some gardeners leave the mixture to soak for a day. Stronger pesticides work faster, but they are also more dangerous to beneficial garden insects. Strain the liquid into plastic storage containers. Use a fine sieve to remove the tobacco and chilli pieces. Dilute in a 1:1 ratio and spray onto affected plants, particularly in the whorl where the worm stays. Top-dress the spray by sprinkling some ash.

Recipe 3: Mix 2 kg of soil with 2 kg of wood ash. Apply a pinch of the mixture in the maize whorls.

The mixture is lethal and kills FAW worms and eggs. The effects of this trial were also quite promising and the maize crop was not badly damaged by FAW. Dosage and mixing rates of the different components need to be precise for uniformity and efficacy.

8. Rabbit urine

Rabbit urine can be used as a fertilizer, insecticide or pesticide. As a fertilizer, rabbit urine contains nutrients such as nitrogen, phosphorus and potassium needed for healthy plant growth. As an insecticide or pesticide, the mixture should be sprayed on affected crops three times per week for two weeks to wipe out the insects. Place one litre of rabbit urine into 20 litres of water. Mix thoroughly and apply to affected plants.

9. Malawian mixture

In **Malawi**, FFS participants have been conducting monitoring, surveillance and validation studies on FAW sustainable management practices through the use of a botanical pesticide mixture of neem, fig-leaf trailing pea (local name: *mphanjovu*) and sisal. Farmers crush neem, sisal and portions of the tuber of *mphanjovu*, soak each of these in water overnight and filter them (two handfuls of crushed biomass or approximately 50 g per two litres of water). The filtrate is poured into plastic bottles with perforated lids and applied directly into the leaf whorls of the maize plants – from the seedling stage up to tasselling. After the tasselling stage, the pesticides are applied directly into the leaf sheaths. If eggs or larvae are still found in more than 20 percent of the sampled crops, then a botanical pesticide is applied.

8.

Farmer field school trial design

8. Farmer field school trial design

FFS groups in Kenya conducted trials on experimental plots to analyse and learn about the effectiveness of different treatment options.

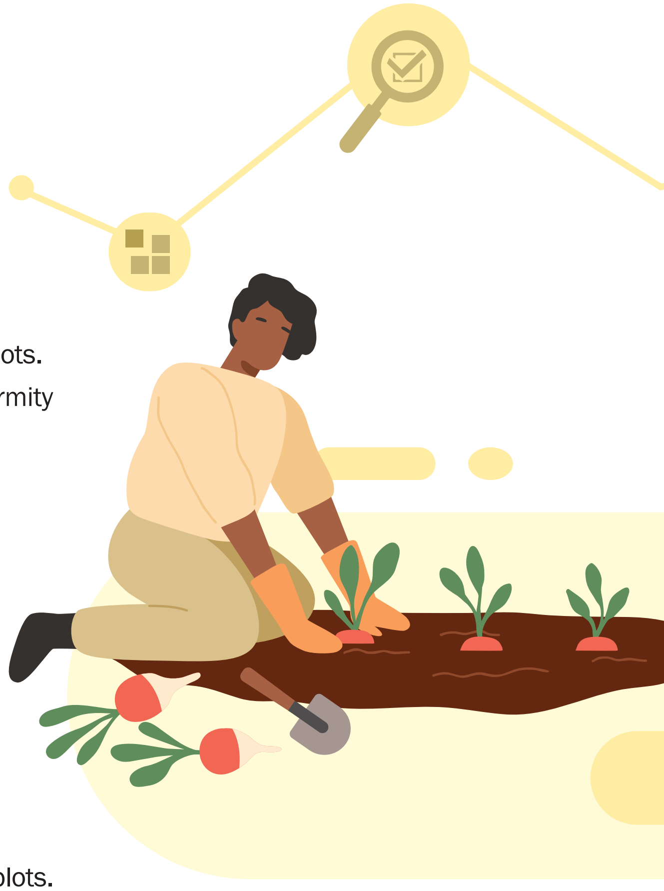


Figure 1 outlines the various treatments used on the maize plots. In conducting trials, FFS groups must ensure aspects of uniformity and consistency to execute the trial effectively:

1. similar agro-ecological zone;
2. similar soil structure;
3. same fertilizer application regime;
4. same maize variety;
5. similar planting and spacing regime;
6. consistent agropractices such as weeding across all plots.

Plot 1	Plot 2	Plot 3	Plot 4
(Treatment) Mexican sunflower extract	(Treatment) Neem extract	(Treatment) Chemical extract	(Treatment) Sodom apple extract
Replication plot 1	**Replication plot 2**	**Replication plot 3**	**Replication plot 4**
(Treatment) Chemical extract	(Treatment) Sodom apple extract	(Treatment) Mexican sunflower extract	(Treatment) Neem extract

Figure 1. Trial design example from an FFS group in Kenya.

9.

Conclusion

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Farmer field schools often utilize cultural activities such as song and dance to share knowledge and culture, build cohesion and learn communication and leadership skills.

9. Conclusion

Prospects for sustainable future FAW management remain within reach. Support to farmers must continue through training in technologies and innovations to manage and control FAW.

Additionally, provision of pheromone traps and lures can assist farmers in monitoring the presence of FAW in their fields. Awareness-raising must continue with local officials and farmers concerning the use of the innovative technologies given to farmers. There is a need to sustain the mechanisms in place to transfer knowledge and skills by those who directly benefited from the project to other farmers who may not have participated in an FFS.

There is no standard model for FAW control and various control options are continuously being tried and tested for efficacy. The FFS approach has proven valuable in FAW capacity building due to its core features of using traditional knowledge, discovery-based learning and group decision-making to test and adapt locally available management options. Participants in FFS can conduct their own pilot exploration of locally available products from the lists above, that can be incorporated as one of the key tools for the IPM of FAW.

The capacities of smallholder farmers should be strengthened through the promotion, preparation, testing and adoption of various control options or combination of options available for FAW management as appropriate. More documents similar to this guide will enhance the knowledge base around sustainable FAW control, eventually leading to widespread use of environmentally friendly management options.


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