Fall Armyworm for Maize Smallholders in Kenya:

An Integrated Pest Management Strategic Plan

Summary of an in-country consultation

November 2019

Katie Murray, Paul C. Jepson and Joe Huesing

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Purpose of this IPM Strategic Plan

The purpose of this strategic plan is to lay a foundation for increased use of integrated pest management (IPM) in order to reduce the economic, health, and environmental impacts of fall armyworm (FAW) and FAW management practices on smallholder maize farmers in Kenya. The plan outlines current management practices for major maize pests including FAW, and critical pest management needs, as informed by farmer and extension worker focus groups. This plan is based on the IPM Strategic Planning consultation method used in the Western United States (Murray & Jepson, 2019).

This plan serves a number of important functions. It can be used to enhance understanding of current practices with respect to pest management in maize-based cropping systems in Kenya, including the current use of pesticides, cultural practices, and biological control. The plan also includes comprehensive and detailed lists of stakeholder-derived critical needs across multiple sectors, which can be consulted and acted upon as a part of a FAW response plan in Kenya.

The document begins with an overview of maize production in Kenya, including background on the invasion of FAW. The remainder of the document is an analysis of current management strategies as reported by the focus group participants. Current management strategies included in this document are those that were reported, and should not be interpreted as management recommendations or assurances of efficacy.

Current management is presented by crop growth stage in an effort to assist the reader in understanding whole-season management practices. The critical pest management needs are presented by crop stage and within thematic groups covering pesticide risk management, research, extension education, and regulatory issues.

Note: *Pesticide active ingredient and trade names for certain pesticides are used throughout this document as an aid for the reader. The use of ingredient or trade names in this document does not imply endorsement of specific products by the authors of the report or by the organizations publishing this report.*

Executive Summary

In an effort to assess the current management status of fall armyworm (*Spodoptera frugiperda*; FAW) in maize production systems in Kenya as well as to identify critical challenges and priorities, a comprehensive in-country consultation was conducted. The consultation included four focus groups with farmers and extension agents from two districts in western Kenya (Busia and Bungoma), a multi-stakeholder meeting with representatives from multiple agencies working to support FAW management country-wide, as well as short informative meetings and interviews with agro-dealers, government officials, and development organizations.

Key Findings

Kenya's well-developed infrastructure, which includies a strong network of agricultural advisors from both public and private organizations, sets the stage for a coordinated national response to this invasive pest. Overall, our consultations revealed a general understanding of the benefits of planting improved seed, the importance of plant nutrition, and the need for rapid response to invasive pest outbreaks. However, capacity in critical areas is limited, as outlined below.

Farmers: The farmers we consulted lacked critical information regarding the FAW life cycle, the role of scouting and monitoring, and the most efficacious treatments and treatment timings against FAW. Farmers are relying on a variety of management tactics based on different approaches to pest management, but these do not seem to be achieving sufficient control of the pest. Beyond FAW, farmers were also concerned with storage technology and pest management options for post-harvest pests including weevils and grain borers, which cause substantial losses.

Based on our consultation, we estimate that 50 to 60% of farmers are commonly applying pesticides to treat FAW as well as a number of other insect pests (such as weevils and cutworms). Farmers are using scarce resources to purchase expensive pesticides that are not likely to be effective against the target pest(s). Pest resistance is also a concern, because some pesticides are used repeatedly throughout the season against multiple pests. These include lambda-cyhalothrin or "Duduthrin," an overused pyrethroid in the Kenyan maize system.

We found that farmers are applying synthetic/chemical pesticides with high risks to human health, birds, mammals, aquatic species, and pollinators, and that these applications take place without the use of personal protective equipment (PPE) or safe application equipment. Most farmers do not have backpack sprayers and instead use hand-held spray bottles or water bottles. We heard several reports of the use of carbofuran ("Furadan"), a highly toxic carbamate that is no longer used in the US, EU, or Canada.

Pesticide selection is limited by what is available in the marketplace, which does not always correspond with current recommendations. Availability itself is limited by product costs, farmer demand, and a lack of critical information and capacity in the evaluation, recommendation, and procurement pathways. Farmers need training on pesticide selection and use based on risks and efficacy, as well as training on effective IPM alternatives including locally-derived and accessible management methods. Limited resources would be much better invested in improved seed, whose higher yields can compensate for FAW losses without the negative impacts of pesticides.

Extension: Although the government extension system in Kenya is well developed, funding cuts have led to reduced capacity. Our consultations revealed one extension worker for every three to four thousand farmers. Private services experience similar challenges, with "plant doctor" ratios of one to every six to eight thousand farmers. This limited capacity makes it incredibly difficult to respond to invasive pest outbreaks in a timely way.

Our respondents also reported that the high ratios of workers to farmers makes education continuity a distinct challenge. Multiple trainings are often needed, and many individual farmers do not return for subsequent sessions. Strategies to expand and improve information delivery with limited budgets and worker capacity are needed.

Agro-dealers: Agro-dealers are a key link in the system, but seem to have very weak connections with government extension and other agencies. Critical extension information and training leaflets do not always reach them.

Despite training on pesticide safety by the Agrochemical Association of Kenya (AAK), none of the agro-dealers we visited had adequate PPE on site. Gloves were not present, and when we asked what PPE was available, one agro-dealer showed us a dust mask, the use of which would actually increase rather than decrease exposure risks. No high-quality or label-recommended masks were in stock.

Spray service providers: Kenya has a developing system of "spray service providers" (SSPs), farmers who have received special training to apply pesticides. This program is directly linked to the member companies of CropLife.

One region we visited did not have an established program, while the other had four spray service providers in the ward, serving 6,000 households. An expanded system with trained SSPs could greatly increase effective FAW management and reduce risks to untrained farmers from pesticides.

Regulatory: In Kenya, the regulation of agriculture is the purview of counties. Thus, control measures and their success are dependent on county level resources and capacity, which vary. Because the FAW has the ability to travel vast distances, there is a need for coordinated, synchronized area-wide responses. The local governments with which we consulted felt that FAW should be given more prominence and focus by the national government to help address the need for a more coordinated response.

We also found many off-label chemicals reported to be in regular use, as well as chemicals banned in Kenya that are regularly brought into the country from neighboring states (e.g., Uganda) and sold.

Research: Our consultation did not include a focus on current research efforts in Kenya. It is important to evaluate the responsiveness and timeliness of research, and the pathways through which findings are fed back to farmers.

Overall Recommendations

- **Public-private partnerships:**
  - Expand the spray service provider program and equip this group with proper training and PPE to reduce the number of farmers applying pesticides without either training or PPE. One county in our consultation (Busia county) had no spray service providers.
  - Increase public-private partnerships and collaborations across private organizations to systematically increase the number of farmers reached and served.
- **Education/Training:**
  - Agro-dealers and spray service providers should be engaged in regular training on pesticide efficacy and risk.
  - Spray service providers need additional training on sprayers, nozzles, and sprayer calibration.
  - Extension and other advising efforts (such as the "village-based advisors" through FIPS) need additional training on scouting and thresholds for FAW.
  - Training and information targeted at all groups (agro-dealers, spray service providers, extension, and farmers) on pesticide selection, application methods and rates is critically needed.
- **Information delivery:**
  - Simplified versions of guidance on scouting, thresholds, and treatment (including pesticides and associated risks) that can be disseminated using technology such as cellular phones are needed.
  - Field radio messaging seems to be an important tool for reaching farmers. Resources are needed for effective dissemination through this mode of information delivery.
- **Research:**
  - FAW damage and impacts to yield need to be quantified for different regions. Some farmers we consulted reported up to 50% losses from FAW.
  - Efficacy testing is critical to identify low-risk pesticides that are also effective against FAW. This should be done in collaboration with governmental and regulatory officials to ensure the legality, affordability, and availability of products.
- **Governmental:**
  - National recognition and classification of FAW as a notifiable pest is needed in order to elicit a more coordinated and concerted response to FAW.
  - Government-provided pheromone traps and area-wide monitoring would assist greatly in local decision making and quantification of pest risks.
- **Regulatory:**
  - Explore possibilities for selling pesticides to farmers in smaller containers, in smaller doses, and with clearly labeled instructions for application, including calibration and PPE requirements for backpack sprayer users.
  - Pesticides that ***require*** PPE in order to be used safely should not be sold unless climate-appropriate PPE is also available, affordable, and sold with these pesticides.

Pesticide Risk Management in Kenya: Key Findings

Based on our consultation, we estimate that 50-60% of farmers are commonly applying pesticides to treat FAW as well as a number of other insect pests (such as weevils, cutworms). During times of heavy FAW infestation, up to 90% of farmers might be choosing to use pesticides as a means of control. We also learned that farmers are applying pesticides to treat pests in other crops, but our consultation focused largely on maize.

Lack of PPE and safe application equipment: We found that farmers are applying pesticides with high risks to human health, birds, mammals, aquatic species, and pollinators, without the use of personal protective equipment (PPE) or safe application equipment. Most farmers do not have sprayers (only a few farmers in our consultation reported owning a 20-liter backpack sprayer, far fewer than those reporting the use of pesticides). Many farmers instead use hand-held spray bottles or water bottles to apply pesticides. Pesticides are commonly mixed in open buckets, and splashed onto plants with brooms or dripped into the whorl using rags or cloths. PPE was not found to be stocked at the pesticide kiosks we visited, which were selling products labeled for use with PPE. It was also clear from our consultations that proper dosage and calibration was not well understood, and that in many cases, farmers were applying much higher doses of the active ingredient than the labeled rates.

Lack of efficacy, potential for resistance: Notably, among the common pesticides farmers reported using against FAW, several are not likely to be effective against this pest. Duduthrin, a product with the synthetic pyrethroid active ingredient lambda-cyhalothrin, is a widely used pesticide against FAW and other insect pests, often applied multiple times throughout the early growing season. FAW is known to have developed resistance to pyrethroid insecticides in other parts of the world where the pest has become established and is being managed (Yu, 1992; Al-Sarar *et al*., 2006; Mota-Sanchez & Wise, 2019). This is likely to be happening in Kenyan systems, and could be exacerbated by over-reliance on this one product for management.

Use of highly hazardous pesticides: Pesticide selection for farmers is limited by what is available in the marketplace, which does not always correspond with current recommendations or even government regulations. We heard several reports about the use of "Furadan," a pesticide containing the highly hazardous active ingredient carbofuran. Carbofuran is one of the most toxic carbamate pesticides available, is banned in Canada and the EU, and is cancelled in the US. This product should not be used by smallholder farmers without PPE or knowledge of how to mitigate the risks to humans and wildlife. Other highly hazardous and even unregistered products come across the border from neighboring countries.

Pre-harvest and re-entry intervals: There is very little awareness of the existence or importance of pre-harvest intervals (PHIs) or re-entry intervals (REIs) associated with the use of pesticides.

Scouting and thresholds: Extension workers and farmers report treatment of FAW when it is found to be present rather than using scouting or threshold-based treatment models to guide treatment decisions (e.g. Huesing *et al*., 2018).

Demand-driven system: The availability of lower-risk pesticides that are also efficacious is limited by cost, farmer demand, and a lack of critical information and capacity in evaluation, recommendation, and procurement pathways. Agro-dealers buy what farmers are asking for, not necessarily what they know works and/or is safe for use without protective equipment. Policies are needed that will increase availability and access to low-risk, efficacious products. Agro-dealers and farmers also need training on pesticide selection and use based on risks and efficacy, as well as training on effective IPM alternatives, including locally derived and accessible management methods. Expansion of the spray service provider system coupled with training could greatly reduce the risks to smallholders and the environment. In the meantime, limited farmer resources would be much better invested in improved seed, whose higher yields can compensate for FAW losses without the negative impacts of pesticides.

Actionable Priorities for FAW Response

Compiled from a FAW Multi-Stakeholder Meeting focused on:

FALL ARMYWORM MANAGEMENT FOR SMALLHOLDERS FARMERS

Supporting the development of IPM capacity to manage FAW in Kenya

The following actionable solutions to improve country-wide management of FAW by smallholder farmers were identified as top priorities by a group of stakeholders that included agency, NGO, government, and private sector participants. We provide a summary of key recommendations below, before outlining the results of the key farmer and advisor consultations.

- Develop trainings for farmers that focus on the importance of early detection of FAW, insect phenology (life cycle and timing), and IPM interventions.
- Develop trainings for farmers and agro-dealers that focus on pesticide selection, responsible use, and disposal. Trainings should cover application techniques and calibration training.
- Train and empower farmers to understand and demand safer and more effective pesticide products.
- Improve the dissemination and packaging of information; revise and republish technical briefs and other information sources and include lessons learned.
- Target interventions to agro-dealers.
- Target and expand the spray service provider (SSP) network with training around pesticide selection, application (including calibration calculations), and the importance of PPE.
- Engage in capacity-building among all stakeholders, and maximize the attendance of trainees.
- Engage multiple stakeholder groups to share responsibility in delivering information regarding the safer use of pesticides.
- Improve national monitoring and information-sharing; increase information-sharing among stakeholders including the Department of Agriculture and Plant Inspection Service.
- Enforce regulation, regulate counterfeit products, and strengthen the agro-dealer certification process.

Participants included representatives from:

Kenya Crops and Dairy Market System (KCDMS), US Agency for International Development (USAID), Center for Agriculture and Bioscience International (CABI), Farm Input Promotions Africa (FIPS-Africa), CropLife Kenya, Agrochemical Association of Kenya, Syngenta, Bayer, BASF, Cereal Growers Association (CGA), Agribusiness Advisors of Kenya, Kenya Plant Health Inspectorate Service (KEPHIS), Kenya Agriculture and Livestock Research Organization (KALRO), Kenya Pest Control Products Board (PCPB).

Farmer and Advisor Stakeholder Consultation Method

The main consultations included discussion, interviews, and focus groups with the following:

RTI Kenya: Review of the history of the FAW outbreak and the local response, including agro-vet and farmer trainings.
Agro-dealers: Three agro-dealer shops were visited in Bungoma and Busia districts. Agro-dealers identified the products preferred by farmers for FAW management. We also examined product packaging and labels, noted available PPE, and discussed agro-dealer training and capacity needs. Agro-dealers also attended our extension focus groups (described further below).
Busia and Bungoma county government: Review of county level capacity, approaches, and needs for improved FAW management with county officials.

Extension consultations:

- Busia District Extension consultation: Focus group session included 24 participants — nine village-based advisors, six agricultural ministry workers, and nine KCDMS/FIPS field officers.
- Bungoma District Extension consultation: Focus group session with extension workers included 15 participants — three village-based advisors (VBAs), three spray service providers (two of which were also VBAs), three agriculture ministry workers, and seven implementing partner representatives from FIPS.

Extension focus group discussions were focused around the following themes:

- Relationship and patterns of engagement with farmers, the scale of their districts, and farmer client population sizes.
- Review of FAW management approaches and the role of extension in farmer support.
- Discussion of farmer needs for FAW management.
- Discussion of extension workers' and agro-dealers' practical, logistical, and capacity-building needs.

Farmer consultations:

- Busia District farmer consultation: Focus group session with 35 farmers (15 female, 20 male).
- Bungoma District farmer consultation: Focus group session with 24 farmers (18 female, 6 male).

Farmer focus group discussions were focused around the following themes:

- Discussion of FAW impacts, management approaches, pesticide use, and pesticide application methods.
- Crop-stage-based review of insect, disease, and weed management and crop production practices.
- Review of farmer needs.

Note: *We would like to thank all of the individuals who have provided information to support this report. We would also like to acknowledge our FIPS colleagues for groundwork and interpretation, as well as the extension workers and farmers who generously gave their time and feedback.*

Maize Production in Kenya and FAW Incidence: An Overview

Maize, which accounts for about 40% of the total crop area of Kenya, is grown primarily for subsistence in the country, and is generally sold immediately after harvest (Njagi Njeru, 2019). An affordable grain, maize makes up about 65% of the total food calories consumed by households in Kenya. For many Kenyans, food security largely depends on a successful rain-fed maize crop. More than 36% of Kenyans are considered to be food insecure (FAO Kenya, 2020), and approximately 1.3 million Kenyans are considered to be at "crisis" or worse levels of food insecurity (USAID, 2020).

Kenya's annual maize production target for the past 10 years has been 40 million bags or approximately 3.6 million tonnes. However, over the past decade, the average production has fallen well below this target. Although 2018 saw the highest recent production, at 46 million bags, Kenya experienced significant deficits in 2019 (Figure 1; FAO, 2019).

Kenyan population trends suggest that production targets should have been above 50 million bags in 2019, reaching 60 million bags by 2025 (Njagi Njeru, 2019). Achieving this level of production will be a challenge given low productivity and the small scale of many maize farms, the impacts of poor production practices including pest control against FAW, and the market distortions created by system actors in the region (Njagi Njeru, 2019).

Figure 1. Cereals Production in Kenya

Kenya				
Cereal Production				
	2014-2018 Average	2018	2019 Estimate	Change 2019/2018
	000 tonnes			Percent
Maize	3,573	4,000	3,400	-15.0
Wheat	243	360	200	-44.4
Sorghum	158	180	155	-13.9
Others	310	361	300	-16.9
Total	**4,283**	**4,901**	**4,055**	**-17.3**

Note: Percentage change calculated from unrounded data.
Source: FAO/GIEWS Country Cereal Balance Sheet.

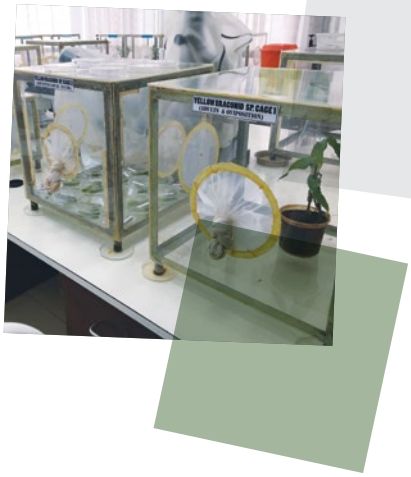
Dependence on weather and rainfall patterns in the production of rainfed maize makes the country vulnerable to supply shortages. Invasive pests such as FAW further threaten this security, which triggers a cascade of reactions that can introduce additional risks to the system.

FAW first appeared in Kenya in 2016. After years of establishment, it is estimated to be present in as much as 75% of Kenyan maize (Sisay, 2019). Yield losses to FAW can vary based on region, weather patterns, and planting dates, but in general losses are estimated to average 30% (e.g. De Groote, 2020).

Governmental responses to FAW have been devolved to the county level, with some counties being better equipped than others. Some extension workers reported that they are responsible to up to four thousand farmers. For the most part, these farmers are widely distributed, often across long distances that require transportation to deliver or receive education. Capacity is needed to strengthen the county-level extension systems' ability to successfully respond to this pest through increased outreach, engagement, and education efforts.

The private sector has well-developed infrastructure in Kenya for invasive pest response. The Agrochemical Association of Kenya (AAK) provides training for agro-dealers and spray service providers (SSPs). Many other training opportunities are provided by the private sector, including training and demonstration through FIPS, training for agro-dealers and extension through KCDMS, and CABI's plant clinic network and plant doctors. FIPS also coordinates and trains a network of "village-based advisors" (VBAs), who work directly with farmers. These VBAs might advise 300-600 farmers, work directly with them, including on the provision of pesticide applications as needed.

Our consultation focused on two western Kenya districts, Busia and Bungoma. In Busia and some areas of Bungoma, farmers can achieve two maize crops per season.



Pest Management Activities by Maize Crop Stage

The following sections outline current pest management activities in maize, organized by major crop stages. The four main crop stages identified by farmers to aid in discussion of management activities are:

Preparation to planting (September–October)
Emergence to vegetative growth (November–January)
Tasseling to maturity (December/January–April/May)
Harvest and post-harvest (April/May–postharvest storage; second harvest September–October)

The areas we visited for consultation in Busia and Bungoma districts varied in seasonality. In Busia, farmers generally plant two maize crops per year. In some areas of Bungoma, such as Kisumu, farmers generally plant only one.

While maize is a common second crop for the areas that can achieve two crop cycles, in some cases farmers plant beans or sweet potatoes in the second season. Maize is often intercropped with groundnuts, cowpea, or beans during the second season, plants which provide both beans and leaves. Most farmers practice "relay cropping," in which sweet potatoes and beans are planted when the maize gets tall, but before harvest. Beans were reported to have severe issues with thrips and aphids.

In addition to FAW, information on other major maize pests and their management are included throughout the following sections as appropriate. These are listed here alphabetically by common name, with species designations from locally relevant literature:

Maize lethal necrosis disease
Common stalk borer (*Busseola fusca*)
African armyworm (*Spodoptera exempta*)
Larger grain borer (*Prostephanus truncates*)
Maize weevil (*Sitophilus zeamais*) (also "blue weevil" and "black weevil" were reported, but the description matched meloid beetles rather than weevils)
Cutworm (*Agrotis* spp. & others)
Termites (multiple species)
Striga (*Striga asiatica, Striga hermonthica, Striga gesnerioides*)
Stem sawfly (species unknown)
Safari ants (*Dorylus* spp)
Vertebrate pests: moles, rats, weaver birds

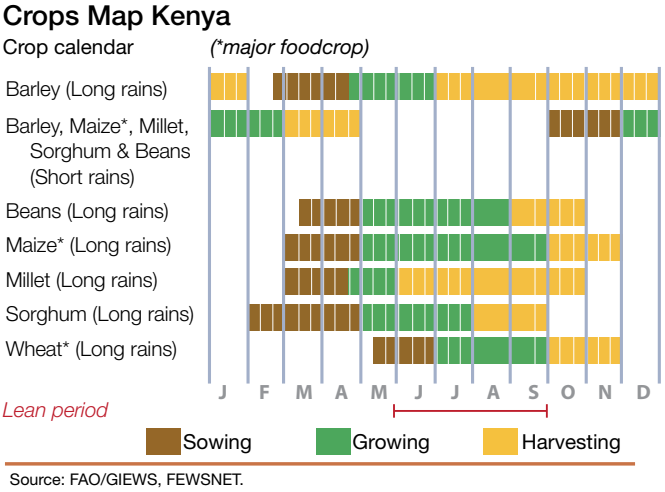
Preparation to planting: (September-October)

Farmers first clear, plow, then harrow fields, and wait for rain for planting. The maize cropping seasons are provided in Figure 2 (FAO, 2019). In Busia, the first season extends from early March to June or July. This season is characterized by "long rains." The second season, a drier season, extends from July/August through early October, and is characterized by "short rains." Planting for the "long rains" season takes place in March, and in July or August for the "short rains" season.

Many growers are using improved seeds, which are a priority for the first season. Improved varieties were reported to increase yields as much as three-fold compared with local varieties.

In the second season, farmers more commonly use local varieties. The second season is not prioritized with improved seed and additional inputs because: 1) rain is much more unreliable during the second or "short rains" season; 2) even with additional inputs, production during the second season is much less than during the first, and the investment value does not pay off for farmers; and, 3) FAW incidence is higher during the short season (although, even before FAW, the second season was not prioritized).

Thus, the "long rains" season is the one generally relied upon for both subsistence and the additional income that allows farmers to purchase improved seed and fertilizer. In times of drought, planting is delayed, and many farmers cannot afford to buy improved seed.



Source: FAO/GIEWS, FEWSNET.

Field activities, pests, and pest management activities:

Break ground
Plow
Furrow
Plant on ridges between furrows (with rains)
Soil test if possible (~50% reported doing so)
Fertilize (more than half of the farmers consulted purchase fertilizer; others use manure)
Farmers weed two to three times during the pre-plant stage.

Critical Needs from Preparation to Planting:

- Farmers need increased access to improved seed varieties, which have higher yields that can compensate for losses to FAW.
- Improved varieties are needed that are suited to different soil types.
- The common use of diammonium phosphate (DAP) fertilizer acidifies soil. Farmers need access to soil analysis tools for testing pH levels. Tests are expensive, but hand-held tools are available and could be made more accessible.
- Farmers need education and clarification on when and how to apply lime (appropriate application rate/acre).
- Farmers need education on the trade-offs between the cost of pesticides and other treatments and inputs required for local varieties versus the cost of using improved seed and fertilizer, which can bring greater long-term returns. Priorites for limited resources are: 1) hybrid seed, 2) fertilizer, 3) crop timing, and 4) chemical inputs. The yield advantage is likely to be greater with the adoption of the first two strategies, followed by the second two if resources allow.

Farmers want to be able to produce their own high-quality seed. The improved seed varieties cannot be saved year-to-year, and must be purchased each season.

Emergence to vegetative growth (November-January)

Field activities, pests, and pest management activities:

Farmers usually weed two to three weeks after planting, when the plants have six to seven leaves and are around six inches high. Two weeks later, when plants are knee-high, farmers add purchased fertilizer as a top dressing (calcium nitrate or CN is commonly used). This is followed by a second weeding one week later, around the 5th week after planting. The majority of farmers weed a third time, and many fertilize a second time (farmers reported that support from One-Acre Fund enables this second fertilization).

Continuous rain suppresses FAW levels and can be beneficial during the first cropping season. Irrigated maize production during the second, drier season does not benefit from this natural suppression and thus requires more intensive management solutions.

Pests and Management:

Fall armyworm: FAW is managed in maize when first noticed, usually when the plants are around knee high. Because the pest can be so devastating, some farmers reported treatment after seeing just one larva. Others said they wait to spray until most leaves are damaged. Busia extension workers reported around two of every five plants are found to be infested by FAW at this stage.

Farmers and extension workers reported multiple management strategies, none used alone. Cultural methods are used in combination with pesticides.

Cultural control and non-pesticide inputs:

- Farmers spray a combination of soap ("Omo") and water using knapsack sprayers; they reported no efficacy.
- Farmers apply ash to the whorl (2kg/ha, 2 days in a row), which has farmer-reported efficacy against other insects including aphids; some farmers reported efficacy against FAW, including more vigorous regrowth without FAW damage.
- Rain is known to suppress FAW.
- Pepper extract is used but was reported to have no efficacy.
- Soil paste is used but is not considered effective.
- Chickens are brought to fields to eat FAW.
- Cooking oil is used to attracts ants which are thought to kill FAW.

Biological control and biopesticides:

- None reported.

Chemical control: Up to 60% of farmers are commonly treating FAW with pesticides. Anywhere from one to three treatments might be applied. Most farmers reported two sprays, 14 days apart, regardless of the product.

- Alibas (alpha-cypermethrin): this pesticide is not known (and was not reported) to have efficacy against FAW.
- Belt (flubendiamide): used and reported as efficacious; not widely available; very expensive.
- Coragen (chlorantraniliprole): used and reported as efficacious; not available.
- Duduthrin (lambda-cyhalothrin): this product is widely used, with no efficacy reported. It is commonly mixed in an open bucket and splashed onto plants with brooms. The use of rags or cloths for application was also reported.
- Escort (emamectin benzoate): used and reported as efficacious; not widely available.
- Furadan/Rocket (carbofuran): reported as used; illegal in Kenya.
- Match (lufenuron): used and considered effective, but not widely available.

- Orthene/Ortran (acephate): used and considered effective.
- Vantex (gamma-cyhalothrin): not widely used.

Note: although efficacy was reported with Belt, Escort, and Orthene, application method and rates varied and did not align with labelled rates or the most efficacious application methods.

Other pests:

Blue weevils, black weevils (probably *Meliodae* spp.): Reported to affect silks. Farmers treat with Belt or Duduthrin, or apply cow dung mixed with ash and water. Physical killing was also reported.
Cutworm (*Agrotis* spp., others): Cutworms are a problem at germination. Farmers reported controlling with one application of Duduthrin, if controlled for. Many don't treat for cutworm.
Common stalk borer (*Busseola fusca*): Farmers reported treating with beta-cyfluthrin (Tremor), a pyrethroid insecticide.
Termites (multiple species) reported, but control not specified.
Striga (*Striga asiatica, Striga hermonthica, Striga gesnerioides*): Reported, but control not specified.
Stem sawfly (pest species not determined): Controlled with fresh cow dung applied to stems.
Safari ants (***Dorylus***): Impacts early plantings; not controlled.
Vertebrate pests: Moles, rats, weaver birds. Weaver birds affect early plantings.

Critical Needs from Emergence to Vegetative Growth:

- Identify and make accessible safe, effective control options for FAW, including access to safe, affordable, and efficacious pesticides and the appropriate application and personal protection equipment (PPE).
- Establish *Striga* as a country-wide, notifiable weed.
- Establish FAW as country-wide, notifiable pest.
- Educate farmers on strategies for increasing soil health and fertility to increase production.
- Extension workers and farmers need training on pest identification, scouting, thresholds, and how and when to respond when FAW is first noticed. This includes training on the importance of early identification and treatment (treating when insects are large and/or when most leaves are damaged is too late for efficacy), identifying and killing egg masses, and timing treatments based on scouting and thresholds.
- Establish effective modes of information delivery to farmers.
- Pesticides:
    - Farmers need training on effective pesticide application methods; some farmers just spray the leaves or frass caps and are not reaching the pest, which stays, covered, inside the whorl.
    - Most farmers didn't know how to interpret the label and are likely not applying products at the correct rates.
    - Farmers reported that there are too many chemicals to choose from, and they do not have access to efficacy information. Support for pesticide selection is needed for agro-dealers, spray service providers, and farmers.
    - Increase the number of spray service providers (SSPs) to reduce or eliminate farmer use of pesticides.
    - Farmers assume that pesticide applications need to be repeated weekly, but this isn't always the case, depending on the pesticide. Education is needed on this topic.
    - Agro-dealers, spray service providers, extension workers and farmers need education on the differences between systemic and contact insecticides and the implications for control of the pest as well as risk reduction.
    - Agro-dealers, spray service providers, extension workers, and farmers need education on the role of natural enemies in managing pests and the impacts of pesticides on natural enemies.

- Conduct efficacy trials for low-risk pesticides, as well as indigenous tactics including soap, ash, dung, and other local strategies
- Develop guidance for appropriate concentrations of effective botanical extracts.
- Promote and enable the use of pheromone traps, with accompanying education on placement and usage.
- Work to correct misconceptions: some farmers think FAW will make the crop stronger.
- Develop area-wide FAW management plans based on collaboration across districts.
- Reduce ratios of extension workers and other advisors to farmers so that farmers can be trained in smaller units, and more farmers can be reached.

Tasseling to maturity (December/January–April/May)

Field activities, pests, and pest management activities:

Second fertilizer application.

Pests and management:

Farmers reported that they do not control for FAW during this timeframe. They often have problems with mongoose eating maize.

Critical Needs from Tasseling to Maturity:

Farmers need additional training on how to scout for FAW infestations at or near tasseling, as well as at the reproductive cob stage. Larvae feeding on tassel pollen can significantly reduce seed set in cobs. Larvae can also be pushed out from whorls when tassels emerge. These larvae may attack young ears. Later, larger larvae may also bore into the maturing cob itself. Scouting and treating FAW at these maize stages is more complicated than at earlier stages, so additional, focused training may be needed.

Harvest and post-harvest (April/May–postharvest storage; second harvest September–October)

Farmers reported either harvesting plants and stacking in the field to dry, or letting plants dry in the ground, then harvesting whole plants or just cobs. Maize is then winnowed.

Field activities, pests, and pest management activities:

Pests and Management:

Maize weevil (*Sitophilus zeamais*): some farmers use Actellic (pirimiphos-methyl) for weevil control in storage. Some use hermetic bags (e.g., PICS bags), and some also reported using dried cow dung and ash for weevil control in storage (2kg of dung/ash mix per 90kg sack, plus a top layer), with efficacy reported. Actellic is often used twice, once at bagging, and again after 3-4 months if weevils are observed in bags.

Critical Needs for Harvest and Post-Harvest:

- Proven strategies need to be implemented, e.g., PICS bags, to reduce storage losses to weevils, which can often exceed losses to FAW. Lack of storage technology leads to high post-harvest losses.
- Farmers need to be made aware of the high risks of aflatoxin that accompanies leaving maize on the soil to dry.
- Dried stalks are often shredded for livestock forage, although these are not as nutritious to animals as they would be to the soil.

Other pest/crop issues of importance:

Sulban (chlorpyrifos): used to control ants in coffee and flowers.

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Appendix: Kenya FAW Pesticide Risk Management Table

The letters below represent four categories of non-target risk potentially affected by pesticide use. If a letter appears in the “Risks” column, it indicates that mitigation is needed at commonly used application rates in order to reduce risk. Risks were calculated using the guideline provided in Jepson *et al.* (2020), which also summarizes proposed mitigations.

This table does not substitute for any mitigations required by the product label.

A= Risks to aquatics: invertebrates and fish

T= Risks to terrestrial wildlife: birds and mammals

P= Risks to pollinators: risk of hive loss

B= Risks to bystanders: e.g., a child standing at the edge of the field

Any product highlighted in yellow is classified as a "highly hazardous pesticide" (HHP) by the World Health Organization and the Food and Agriculture Organization of the United Nations (Jepson *et al.*, 2020). These products may pose significant risks to human health or the environment, and risk reduction measures may not be effective in mitigating these risks.

Pesticides used (active ingredient followed by example commercial name in parenthesis)	Risks requiring mitigation	Average reported number of applications per crop stage				Target pest(s)	Comments
		Preparation to planting	Emergence to vegetative growth	Tasseling to maturity	Harvest to post-harvest & storage		
Compounds or natural products used against FAW in maize							
Alpha-cypermethrin (Alibas)	A, P		2			FAW	No efficacy; sprays 14d apart
Acephate (Orthene, Ortan)	T, P		2			FAW	Effective; sprays 14d apart
Ash			2 (1 day apart)			FAW	Variable efficacy
Carbofuran (Furadan)	A, T, P, B		2			FAW	Treatments 14d apart
Chlorantraniliprole (Coragen)			2			FAW	Effective, sprays 14d apart, not available
Emamectin benzoate (Escort)	A, P		2			FAW	Effective, sprays 14d apart, not widely available
Flubendiamide (Belt)			2			FAW, weevils (possibly misidentified Meloidae)	Effective, sprays 14d apart, expensive, not widely available
Gamma-cyhalothrin (Vantex)	A		2			FAW	Sprays 14d apart; not widely used
Lambda-cyhalothrin (Duduthrin)	A, P		1 (during emergence); 2 (FAW)			Cutworms at emergence; FAW, weevils (possibly misidentified Meloidae)	Not considered effective against FAW; sprays 14d apart
Laundry detergent (OMO)			1-2			FAW	No efficacy
Lufenuron (Match)	A, P		2			FAW	Sprays 14d apart; not widely available
Oil (cooking)			1-2			FAW	May attract ant predators
Pepper extract			1-2			FAW	No efficacy
Soil paste			1-2			FAW	No efficacy
Compounds or natural products used against other maize pests							
Beta-cyfluthrin (Tremor)	A, P		1-2			Common stalk borer (Busseola fusca)	
Cow dung (mixed with ash)					2	Maize weevils	Effective; treatments 3-4 months apart
Pirimiphos-methyl (Actellic)	A, T, P, B				2	Maize weevils	Effective; treatments 3-4 months apart

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