Communication Strategies and Effects on Fall Armyworm Management in Uganda

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Disclaimer

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Abbreviations

AGRA	Alliance for a Green Revolution in Africa
CABI	Center for Agriculture and Bioscience International
CIMMYT	International Maize and Wheat Improvement Center
DARS	Department of Agricultural Research Services
FAO	Food and Agriculture Organization of the United Nations
FAMEWS	Fall Armyworm Early Warning System
FAW	Fall Armyworm
FLC	Farmer Learning Centre
GAP	Good Agricultural Practices
GMO	Genetically Modified Organism
ICT	Information Communication Technologies
IPM	Integrated Pest Management
IVR	Interactive Voice Response
MAAIF	Ministry of Agriculture, Animal Industries, and Fisheries
NARO	National Agriculture Research Organization
NGO	Non-Governmental Organization
PPP	Public Private Partnership
PSP	Private Service Provider
RQ	Research Questions
SMS	Short Message System
USAID	United States Agency for International Development

Executive Summary

Fall Armyworm (FAW) was first reported in Africa in 2016 and has since been associated with causing severe levels of crop damage. As awareness of FAW emerged within Africa, national and regional interventions were implemented, and teams were organized to coordinate investments, policies and strategies.

The first instances of the FAW in Uganda were reported in 2016. Starting in 2017, the Ministry of Agriculture, Animal Industries and Fisheries (MAAIF) responded by training field staff in FAW control and organized a National Task Force that drafted management strategies and control methods for the nation's FAW response. In partnerships with the Center for Agriculture and Bioscience International (CABI), MAAIF and the National Task Force then rolled out a national campaign to disseminate FAW information. This campaign focused on identification, prevention, monitoring, and control of FAW through an Integrated Pest Management (IPM) approach that includes the use of general Good Agricultural Practices (GAP), physical and mechanical controls, and the use of synthetic pesticides in instances where over 20% of plants are infested. Using technical guidance, MAAIF and Uganda's National Agriculture Research Organization (NARO) conducted trainings for extension staff, farmers, and agri-input dealers and distributed FAW management posters and flyers to district agricultural offices. In addition to the broader information campaign, the MAAIF, along with CABI, Farm Radio International and several other partners, piloted a FAW-specific information campaign that utilized Information-Communication Technologies (ICT) to facilitate extension and reach farmers at scale in three Western districts in Uganda.

While the aforementioned information campaign had the potential to inform farmers and affect FAW management behaviors, there remained a need to assess its reach and effectiveness, especially among farmers of different economic segments. The main aim of this study was therefore to assess the information campaign and how it affected the incidence and severity of FAW-related losses in Uganda in order to identify approaches that are most effective at disseminating knowledge of FAW management, while providing mechanisms to solicit input and feedback from the range of farmer economic levels. The specific research questions (RQs) addressed by this study were:

1. Where did farmers of different economic segments access information to control FAW?
2. What management practices did farmers adopt based on the FAW information they received?
3. What are the results of farmers' actions to control FAW?
4. How do farmers of different economic segments share information, provide feedback, and request further information on FAW control?

Data was collected through a combination of (1) literature review; (2) in-country surveys with farmers from different economic segments; and (3) in-country semi-structured interviews with key informants. The districts of Masindi, Kiryandongo, and Iganga were selected because of their importance for maize production, potential for evaluating different wealth segments, and differential targeting for national FAW information campaigns. The study used a purposive stratified sampling approach to select diverse farmers in each district based on varying sizes of maize production and different wealth segments. Only farmers who produced maize and had experienced a FAW infestation in the past growing season were selected.

Two teams of data collectors conducted 409 surveys from farmers in the three districts, plus six interviews with larger farmers who cultivated at least 20 hectares of farmland. In addition, qualitative key informant interviews were conducted with 60 farmers and with MAAIF, NARO, CABI, the three district offices, agro-dealers, and maize processors. Survey data was analyzed

using statistical and qualitative approaches, and farmers were disaggregated into economic segments using a wealth index. The index was based on ownership of livestock and selected household possessions, with each item given a weight to reflect its monetary value.

Results were as follows:

Farmer access to FAW information

Information channels: While Uganda's information campaign provided farmers several possible channels for FAW management guidance, the most commonly used were through neighbors and friends (32% for non-chemical IPM practices and 36% for pesticide information), farmer groups (29% and 30%), and extension workers (25% and 32%). Media channels such as social media, SMS, IVR calling, and printed materials had very limited use, although some farmers used radio (14% and 22%).

Trends related to chemical control methods are particularly valuable because they represent not only awareness, but a behavior change for Ugandan farmers who would not likely have used chemical control methods for their maize crops prior to FAW. Approximately 70% of farmers were using chemical methods to control FAW, indicating the effectiveness of the MAAIF Task Force's FAW information campaign in changing farmer habits.

Wealth and gender implications: Wealth and gender were key determinants for information sources. More affluent farmers accessed information through a broader range of sources and had better access to extension agents. Farmers in low wealth segments, as well as women, accessed fewer information sources and relied primarily on secondhand information through farmer groups and family networks. This finding could mean that poorer farmers may face barriers and are not always in groups supported by extension agents. ICT approaches also seemed affected by wealth, with ownership of a TV, radio, or phone often a prerequisite for these communication modalities.

Information preferences: When asked why farmers preferred certain sources, the majority responded that they preferred to access information from farmer groups because of the perceived trustworthiness of the information and accessibility. Information imparted by extension and channeled through farmer groups provided the most accessible and trustworthy avenue for farmers to receive and share information.

FAW management practices adopted

Non-chemical IPM methods: After receiving information, farmers adopted management practices at different rates. Non-chemical IPM approaches such as cultural, physical, and mechanical controls were adopted by 71% of farmers to control FAW, and they were equally used by farmers across the different economic segments. The two most used non-chemical control IPM methods to control FAW were hand-picking and crushing the larvae (52%) and using quality seed of improved varieties (24%).

Chemical pesticides: Perhaps the most important FAW management approach promoted by the MAAIF Task Force was for farmers to use chemical pesticides to control FAW infestations. Despite this being a notable change in production which incurred new costs, 67% of smallholders and 100% of large farms indicated they had used chemical pesticides to manage FAW. Based on these results, the campaign was extremely effective in supporting a major transition to chemical FAW control.

Trends also appear based on wealth, with the wealthiest quartile of farmers (76%) more likely to be using pesticides compared with low-income farmers (50%). Geography also influenced pesticide use, as more pesticide was used in Masindi (86%) and Iganga (80%) compared with Kiryandongo (38%), perhaps due to fewer extension personnel, distance from major markets and roads, lower overall wealth, or potential differences in the impact of the pest in these geographies.

When farmers sprayed, adherence to the guidelines varied. On average, only 24% of respondent farmers sprayed on the recommended fixed time schedule. The data did show that farmers who sprayed were likely to follow the MAAIF guidance and spray three times, although many farmers sprayed once, twice or four times. Financial constraints likely contributed, as farmers in lower wealth segments tended to under spray while wealthier segments tended to spray more than three times. Men also used chemical pesticides more often than women. Similarly, dosage varied widely, and under-dosing was common among low-income farmers, either due to a lack of cash, a lack of clear guidelines, or both. This type of behavior can lead to insecticide resistance.

However, while farmers may not have followed all recommendations related to chemical pesticide application, they appeared to have followed instructions that were not dependent on their financial capacities. Nearly 100% of farmers adhered to the recommended time of day to spray, which was in the morning and afternoon. The majority (71%) also sprayed correctly with the nozzle targeted on the plant whorl.

Homemade FAW control products: In addition to commercial chemical pesticides, some farmers also tested and used various homemade products to control FAW. These products were made from locally available materials and referred to as “biological products” or “biological sprays” in Uganda although they do not employ biocontrol agents. The most used homemade product to control FAW was ash (9.8%), followed by the combination of ash, pepper, and sand (5.4%). Use of homemade products cut across wealth levels, and there was no discernible trend based on economic level, as farmers in all segments tested these methods.

Other Good Agricultural Practices: Beyond management practices that directly targeted FAW, the MAAIF and Task Force also emphasized general GAPs, also part of the overall IPM strategy, that lead to overall plant health and made crops more resilient to FAW damage. Though farmers indicated that early planting (70%) was the single most useful cultural practice to control FAW, large numbers of farmers were also effectively using weeding (86%), early planting (70%), proper spacing (66%), and crop rotation (61%) to control FAW. The use of these GAPs was similar across all farmer wealth segments.

Results of farmer FAW control

Impacts on production and yield: As farmers took steps to manage FAW, different outcomes were reported in terms of their production and yield changes. While maize accounted for nearly 80% of farmers’ total farmland in all three districts prior to the FAW infection, at the onset of the FAW outbreak and before any interventions were introduced, many farmers quickly allocated land to other crops. Land area planted to maize decreased less in Kiryandongo likely because of maize’s higher importance as a food crop in that district relative to the other two districts. Yields also dropped substantially, from a 2,869 kg/ha average across the three districts before FAW, to 1,700 kg/ha the first year of the outbreak, and then to 1,750 kg/ha after management interventions were adopted. This posed financial challenges for farmers who must invest in FAW control despite considerably lower yields.

Adoption of different FAW control approaches and yield implications: When examining the implications of FAW control approaches, there was a close relationship between the levels of adoption and yield. Across the various wealth segments, data indicate that adherence to chemical pesticide recommendations tended to be most effective in mitigating yield loss. Higher economic segments tended to adopt management approaches at higher levels and saw corresponding reduction in yield losses.

Women, who have more limited access to information than men and tended to be poorer, were less likely to practices the correct use of chemical pesticides, used lower dosage rates, and did not spray three times. They also showed lower yields than men, likely because of the aforementioned factors.

Farmer information sharing and feedback

Data emerged on (1) whether there were feedback loops in the information system that allowed farmers to learn and share their experiences on how best to control FAW, and (2) whether their ideas and learning could be used to influence future FAW programming and perhaps even affect policy.

The first step toward an effective agricultural information system is for farmers to share their feedback and learning with others. Indeed, 70% of respondents reported that they shared information on their experiences with others. The most common response was that farmers shared with neighbors, friends, and family (56%), followed by extension workers (26%). Among ICT approaches, only radio (56%) was used to provide feedback with any consistency. There was very little interaction via digital systems such as social media and SMS, and no respondents used the Plantwise factsheet app to share feedback. There was a clear effect of economic segments on farmers' ability and willingness to provide feedback and share learning with others. Few low-income farmers reported sharing with extension, possibly due to lack of direct access. The feedback loops appeared to work better for the wealthier and larger farms. Similar trends were found with the use of ICTs, where there was a strong correlation between wealth and the use of radios and phone, because ownership of both is needed to ask questions in radio feedback sessions.

The feedback loops that did exist, however, appeared to be more about responding to questions asked by farmers, rather than extension agents or researchers systematically receiving information or learning from farmers which they could use and feed back into their systems. The inference was that a top down extension process appeared to be working in terms of verifying official information, but the learning system was not able to harvest information and accelerate innovation based on farmer-led feedback.

Summary of findings

Results from the study can be summarized as follows:

- Farmers prioritize accessibility and trustworthiness in sources of information.
- Groups were preferred venue for information sharing.
- MAAIF's FAW information campaign was effective in changing farmer behaviors.
- Additional guidance is needed on chemical pesticide use.
- Farmers are actively experimenting.
- There was a reduction in maize yield loss following the FAW campaign.
- Costs for different FAW control approaches are prohibitive for some farmers.
- Learning and feedback mechanisms are weak.

The following recommendations provide options for enabling Ugandan farmers to better control FAW:

Promote farmer groups and Farmer Learning Centers: Groups were farmers' preferred channel for accessing information and enabling feedback based on convenience and trustworthiness. Yet farmer groups are not new and face many constraints to effectiveness. Nevertheless, if most farmers indicated that they prefer groups to learn, then a new approach to farmer groups is required. For farmer groups to work for FAW management, they need to not only serve as an entry point for management information but also a forum for collaboration, peer-to-peer learning, and innovation. The Farmer Learning Centre model could provide an alternative to the top down process found in traditional extension approaches and could create an opportunity for farmers to learn about new technologies, test them with colleagues and put them into practice. Extension campaigns will need to ensure that the benefits of groups are equitable and that groups are inclusive of low-income farmers, youth, and women.

Use ICTs and social media more effectively: Despite the potential role of ICTs in sharing FAW control information, the mass communication platforms used by the campaign had limited reach amongst the surveyed farmers. Lack of equipment such as phones and radios, education levels and language barriers contributed to low adoption rates. Some of these issues could be overcome if farmer groups take advantage of members with greater access to and capacity with technologies. For example, wealthier, educated, and better equipped farmers can receive this type of information and then set up mechanisms to share with others group members. Younger farmers who have better digital skills could also facilitate access to information from social media platforms.

Support diverse farmer segments: General advice is essential to communicate key messages quickly to the farmer community. However, uptake of and response to information is largely based on local contexts and the options, skills, and financial levels of farmers. Therefore, information needs to be tailored with consideration of these factors. For example, if farmers cannot afford to implement a the entire FAW control "package," guidance could highlight the most essential elements of the FAW control approach that everyone should strive to achieve. If farmers only want to use locally made control methods, recommendations should cover which ones show the most promise.

Improve options for women: The survey revealed that women were generally less wealthy than their male counterparts and were less able to access information, all of which contributed to women using fewer FAW control approaches and achieving lower yields. The results also suggest that if more women belonged to groups or were given the option to join savings groups, they would have more opportunities to save, access credit, and access valuable information.

Facilitate better adherence to chemical regimes: Farmers responded in large numbers to the MAAIF guidance to employ pesticides in cases where pest levels exceeded 20%. However, the guidance also contained gaps that caused some farmers to deviate from recommended application approaches. To help farmers use the chemicals more efficiently or effectively, the next round of FAW guidance should include additional details such as specific rates based on pest growth stage to close these gaps.

Assess farmer innovation and homemade solutions: Farmers were both (1) experimenting with a diverse range of pesticides, applying various doses, and mixing chemicals; and (2) testing homemade control methods to identify alternative, more affordable options. However, there was little evidence that extension or research valued or captured these local experiments within the existing learning system, even as NARO cited its own research on biological controls. This research can be done in partnership with farmers who can test farmer-developed approaches on co-managed plots. Findings could be incorporated into the national research agenda around FAW and could potentially become formal recommendations for FAW control. Research is being done on these alternative control methods in other places (e.g. Malawi), and actors in Uganda could look to leverage those learnings.

Help farmers better understand and manage the economics of FAW control: As newer technologies are introduced, greater attention needs to be given to helping farmers understand the costs and benefits of adopting technologies and how to more effectively link to markets. Efforts to build financial literacy skills may also prove effective in helping farmers to budget for and/or afford more effective FAW control measures. The Private Service Provider (PSP) model has shown promise with building financial literacy skills and enabling farmer groups to build their investment and productivity capacities.

Strengthen farmer feedback mechanisms: While farmers were innovating, experimenting, and sharing feedback with peers, within groups, and with extension agents, the extent to which this feedback informed broader programming or policy is unclear. More could be done by extension agents and researchers to gather and incorporate data into the larger agricultural information system for FAW control. Efforts to strengthen farmer feedback can therefore lead to a more demand-driven extension system that better meets farmers' FAW management needs.

Refine the FAW control information campaign: MAAIF's information campaign has been successful in providing farmers with FAW control options, changing behaviors, and helping to reduce yield loss. Yet more could be done to improve the level of technical guidance provided to farmers. It is recommended that MAAIF continue working closely with the international research community, private sector, and specialized groups, such as Feed the Future Innovation Labs, to explore additional control measures. Incorporating guidance on natural enemies to the FAW and alternative control methods based on research conducted by NARO and elsewhere may be one option for strengthening the information campaign, as could efforts to incorporate FAW resistant maize varieties.

Develop and/or strengthen information and learning centers for FAW: Developing and building on existing clearinghouses for FAW and other invasive species control, such as those created by CABI, USAID (Agrilinks), and the FAO, where scientists and field practitioners could conveniently access information, learn from a broader set of actors, and avoid duplicating efforts can assist with updating communication materials and support recommendations based on new evidence.

Introduction

Background

Fall Armyworm (FAW) was first reported in Africa in 2016 and has since been associated with causing severe levels of crop damage (Georgen, et al. 2016). Given that this was a new pest in the region, there were many challenges in terms of gathering information, generating knowledge products, and sharing actionable guidance among key stakeholders such as governments, farmers, the development community, and the private sector.

As awareness of FAW emerged within Africa, national and regional interventions were implemented, and teams were organized to coordinate investments, policies, and strategies. At the continental level, FAW control was coordinated by the Food and Agriculture Organization (FAO), which worked with Governments, the U.S. Agency for International Development (USAID), research organizations, non-governmental organizations (NGOs), and development agencies to formulate a continent-wide response. USAID also took a leading role in combating FAW in Africa, and they released the *Fall Armyworm in Africa: A Guide for Integrated Pest Management* in January 2018 (Prasanna, et al. 2018). To complement existing efforts, USAID also established a Fall Armyworm Task Force with workstreams to support (1) pesticide risk reduction; (2) host plant resistance; and (3) knowledge dissemination.

CRS worked with USAID to support the knowledge dissemination workstream, engaging with a number of partners to share perspectives within the global context to fight Fall Armyworm. On February 7, 2018, USAID and CRS co-hosted the Fall Armyworm Forum, an expert dialogue attended by 50 people from the U.S. Government, NGOs, universities, and the private sector who shared information on the severity of FAW in sub-Saharan Africa. Potential management solutions, communications approaches to farmers and experiences from the field in dealing with the pest were also discussed. One of the main goals of this meeting was to learn how project teams were testing short-, medium-, and long-term control measures, such as those outlined in USAID's FAW Guide, and to share recommendations with partners and farmers to reduce crop losses.

The Fall Armyworm Forum identified the following action areas where partners could make rapid and meaningful contributions to FAW control:

1. Establish a clearinghouse for collation of FAW news/ideas and provide a platform for information sharing with a focus on USA based agencies and linked projects.
2. Train country teams in monitoring FAW and support IPM responses.
3. Support a research agenda to assess the effectiveness of local and formal solutions to FAW.
4. Establish two-way communication channels to enhance farmer awareness while giving them a voice.
5. Intensify country-level policy dialogue to support intervention packages for a range of farmer segments.

Since this meeting, several organizations have put plans into action and launched various information campaigns that leverage mass communication tools and more traditional methods of farmer education. To gauge the impact of these efforts, CRS, USAID, and the Alliance for a Green Revolution in Africa (AGRA) proposed a study on how farmers are currently accessing, acting upon, and feeding back information related to FAW control. While FAW has caused crop losses in many parts of Africa, Uganda was selected for the study specifically because a well-coordinated response effort and information campaign was executed there.

Fall Armyworm in Uganda

The first instances of the FAW in Uganda were reported in 2016 by one of the farmer plant clinics, diagnostic centers provided by MAAIF and technically supported by CABI. However, the outbreak was not announced until 2017, as it took time to diagnose this new pest that was initially confused with the other known pests such as the African armyworm or stalk borer. By late 2017, 75% of Uganda's maize crop had been infested by FAW (FAO and ASARECA 2018). Once it became clear that the FAW was a unique pest, farmers began experimenting with homemade products and sprays such as detergent and ash mixtures in attempt to control the pest as most of the available pesticides in the market were not effective.

Uganda's response to FAW

Starting in 2017, the MAAIF first responded by training field staff in FAW control through participation in the emergency East African regional FAW training conducted by the FAO and the International Maize and Wheat Improvement Center (CIMMYT). A Uganda National Task Force was subsequently organized, including 17 experts from NARO, farmer organizations, NGOs, private sector actors, the Ministry of Justice, and the Ministry of Environment. The task force drafted the following strategies in response to FAW:[1]

Photo 1. A FAW-infested maize plant.

- Initiate FAW scouting, monitoring, and an early warning system.
- Introduce effective chemical pesticide protocols by providing demonstrations to farmers and agro-dealers, and supporting procurement of inputs including pesticides, pumps, and protection gear for districts staff.
- Develop awareness and sensitization materials and outlets, including demonstrations and talks by extension agents with farmer groups, in addition to providing the districts with printed materials, radio and TV talk shows, and press conferences.
- Strengthen ongoing research by NARO, in collaboration with the MAAIF and FAO, on biological control and natural enemies of FAW.
- Establish a coordination body between MAAIF and local government task forces.

To ensure a unified response to implementing the above strategies, all FAW-related messaging and control methods promoted by the MAAIF and other stakeholders were expected to align with these recommendations, and all proposed interventions required approval from the National Task Force. This approach was designed to ensure that all trainings for extension staff and any materials that were disseminated were compliant with current information, validated and standardized.

To support awareness building around FAW, MAAIF rolled out a national information campaign. They worked with task force member, CABI, to develop materials and disseminate information including a technical brief to guide extension workers and higher-level management personnel.[2] The main messages focused on identification, prevention, monitoring, and control of FAW.[3] They also created videos; wrote press releases; placed radio

[1] Interview with MAAIF representative, February January 20, 2020, Entebbe, Uganda
[2] For an example see: https://www.cabi.org/isc/FullTextPDF/2018/20187200504.pdf
[3] Interview with Christine Alokit, CABI, on January 20, 2020, Entebbe, Uganda

adverts; participated in TV talk shows; and printed posters, flyers, and brochures that were distributed to district agriculture offices as the basis for extension messages.[4] Farmers were able to access information about FAW control methods from trained extension workers, who also provided demonstrations to farmer groups. NARO also led capacity building efforts, and by 2019 had trained 1,965 farmers, extension officers, and input dealers.

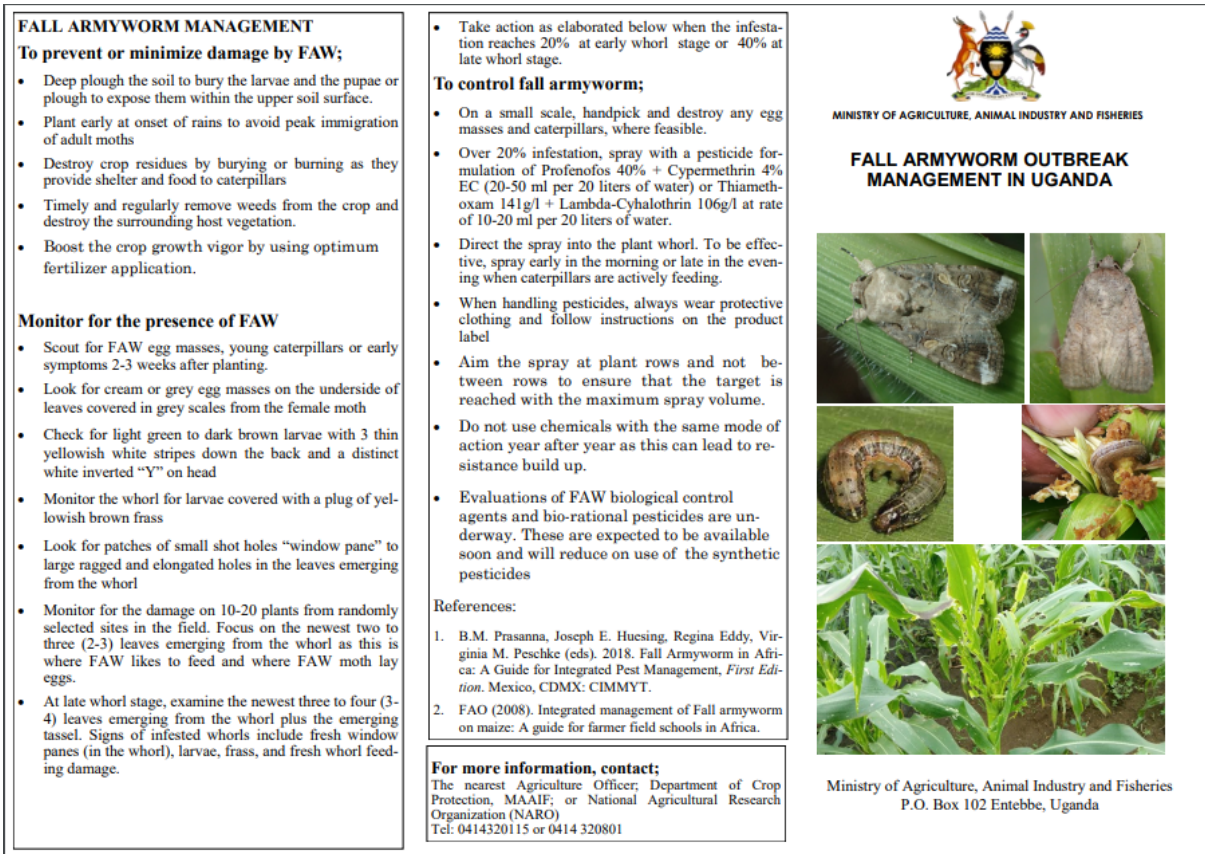
The National Task Force's messaging focused on identification, prevention, monitoring, and control of FAW through an Integrated Pest Management (IPM) approach made up of (1) non-chemical control methods including cultural, physical and mechanical controls; (2) synthetic pesticides; and (3) other GAPs. More specifically, the messaging included the following:

1. **Non-chemical control IPM practices** included learning how to identify and scout for FAW and then how to monitor FAW levels during the growing season. If eggs were found, farmers were advised to crush eggs. For heavily infested plants, farmers were advised to remove and bury or burn crop residues and to deep plough soil at the end of the season to bury larvae.
2. **Use of chemical pesticides** was advised when FAW had infested more than 20% of the crop. The MAAIF initially recommended the use of two pesticides, "Roket" and "Striker." Use of regular chemical control for maize was a new practice for maize farmers in Uganda.

Other Good Agricultural Practices were also promoted as part of the overall IPM strategy to boost yields and to encourage healthy plants that would be better able to withstand FAW damage. Key practices included adoption of quality seeds including hybrid maize, early planting, proper plant spacing, timely weeding, and use of fertilizer, which is particularly important for farmers who plant hybrid maize. Non-chemical IPM practices were prioritized in recognition of human and environmental health risks associated with pesticide use and potential misuse. Official recommendations were to use chemical pesticide only when over 20% of plants were infested (Figure 1). 5 However, the initial pesticide recommendations did not include specific information about total number of sprays, intervals between sprays, and did not give clear dosage rates based on pest development stage.

[4] To see the video on FAW management in Uganda: https://www.youtube.com/watch?v=p05C1q2HRrg
[5] For the entire pamphlet see: http://agriculture.go.ug/wp-content/uploads/2019/05/FAW-Brochure_MAAIF_DCP_revised_April_2018.pdf

Figure 1. MAAIF FAW management flyer



FALL ARMYWORM MANAGEMENT

To prevent or minimize damage by FAW;

- Deep plough the soil to bury the larvae and the pupae or plough to expose them within the upper soil surface.
- Plant early at onset of rains to avoid peak immigration of adult moths
- Destroy crop residues by burying or burning as they provide shelter and food to caterpillars
- Timely and regularly remove weeds from the crop and destroy the surrounding host vegetation.
- Boost the crop growth vigor by using optimum fertilizer application.

Monitor for the presence of FAW

- Scout for FAW egg masses, young caterpillars or early symptoms 2-3 weeks after planting.
- Look for cream or grey egg masses on the underside of leaves covered in grey scales from the female moth
- Check for light green to dark brown larvae with 3 thin yellowish white stripes down the back and a distinct white inverted "Y" on head
- Monitor the whorl for larvae covered with a plug of yellowish brown frass
- Look for patches of small shot holes "window pane" to large ragged and elongated holes in the leaves emerging from the whorl
- Monitor for the damage on 10-20 plants from randomly selected sites in the field. Focus on the newest two to three (2-3) leaves emerging from the whorl as this is where FAW likes to feed and where FAW moth lay eggs.
- At late whorl stage, examine the newest three to four (3-4) leaves emerging from the whorl plus the emerging tassel. Signs of infested whorls include fresh window panes (in the whorl), larvae, frass, and fresh whorl feeding damage.
- Take action as elaborated below when the infestation reaches 20% at early whorl stage or 40% at late whorl stage.

To control fall armyworm;

- On a small scale, handpick and destroy any egg masses and caterpillars, where feasible.
- Over 20% infestation, spray with a pesticide formulation of Profenofos 40% + Cypermethrin 4% EC (20-50 ml per 20 liters of water) or Thiamethoxam 141g/l + Lambda-Cyhalothrin 106g/l at rate of 10-20 ml per 20 liters of water.
- Direct the spray into the plant whorl. To be effective, spray early in the morning or late in the evening when caterpillars are actively feeding.
- When handling pesticides, always wear protective clothing and follow instructions on the product label
- Aim the spray at plant rows and not between rows to ensure that the target is reached with the maximum spray volume.
- Do not use chemicals with the same mode of action year after year as this can lead to resistance build up.
- Evaluations of FAW biological control agents and bio-rational pesticides are underway. These are expected to be available soon and will reduce on use of the synthetic pesticides

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1. B.M. Prasanna, Joseph E. Huesing, Regina Eddy, Virginia M. Peschke (eds). 2018. Fall Armyworm in Africa: A Guide for Integrated Pest Management, *First Edition*. Mexico, CDMX: CIMMYT.
2. FAO (2008). Integrated management of Fall armyworm on maize: A guide for farmer field schools in Africa.

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Tel: 0414320115 or 0414 320801

MINISTRY OF AGRICULTURE, ANIMAL INDUSTRY AND FISHERIES

FALL ARMYWORM OUTBREAK MANAGEMENT IN UGANDA

Ministry of Agriculture, Animal Industry and Fisheries
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In addition to these officially recommended practices, MAAIF and a lead FAW researcher from the National Crop Resources Research Institute of NARO indicated also evaluated the efficacy of biological control agents such as parasitoids and entomopathogens and biorational methods, such as neem, in controlling FAW (some trials are ongoing).[6] They have also conducted maize varietal screenings for FAW resistance. The aim of these studies was to assess the potential for decreasing dependence on synthetic pesticides by using alternative control methods. However, MAAIF did not provide bio-controls in their recommendations, as their efficacy was not known at the time, and there was insufficient research evidence to support broader use.

In addition to the broader information campaign, MAAIF, CABI, Farm Radio International and several other partners piloted a FAW information campaign that utilized ICTs to facilitate extension and reach farmers at scale in three Western districts of Uganda (Tambo, et al. 2019). Channels employed by the ICT-based campaign included radio programming with options for call-in, SMS messaging, and mobile video.

The Task Force's efforts were also supported by the Food and Agriculture Organization of the United Nations (FAO) who funded a two-year project called Support to Enhance the National Capacity for the Management of Fall Armyworm. This project utilized the Farmer Field School (FFS)

[6] Interviews with MAAIF representative, February January 20, 2020, Entebbe, Uganda and with Dr. Michael Otim, National Crop Resources Research Institute, February 6, 2020, Numalonge, Kampala, Uganda

approach and further contributed to strengthening awareness, promoting institutional coordination, and promoting IPM measures (FAO 2018) . It also established a community based FAW monitoring and Early Warning System (FAMEWS) initiative that deployed 126 mobile phones to 15 districts in Uganda to be used to monitor and report on the presence of FAW. FAMEWS aligned with a larger, USAID-funded program in East Africa focused on creating FAW monitoring, forecasting and early warning systems.

Study objectives

This study follows the substantial efforts of the MAAIF and the National FAW Task Force to sensitize and train farmers in FAW identification, monitoring, and management. It also builds from efforts by CABI to measure the effectiveness of their FAW communication campaign in the Midwestern districts of Uganda (Tambo, et al. 2019).

The CABI study evaluated how the ICT-enabled extension campaign contributed to increased FAW knowledge of FAW and adoption of technologies and practices to control the pest. However, it did not evaluate outcomes of the implementation of those practices nor did it disaggregate based on economic segment.[7] Furthermore, CABI evaluated a narrow range of three ICT communication channels but did not evaluate farmers' use of additional channels such as conventional extension, groups, etc.

The main aim of this study was to assess the information campaign in more depth and how it affected the incidence and severity of FAW-related losses in Uganda in order to identify approaches that are most effective at disseminating knowledge of FAW management, while providing mechanisms to solicit input and feedback from the range of farmer economic levels. The specific Research Questions (RQs) addressed by this study were:

1. Where did farmers of different economic segments access information to control FAW?
2. What management practices did farmers adopt based on the FAW information they received?
3. What are the results of farmers' actions to control FAW?
4. How do farmers of different economic segments share information, provide feedback, and request further information on FAW control?

Gathering this information will help inform future approaches to FAW management campaigns in both Uganda and more broadly.

Methods and Limitations

Data were collected through a combination of (1) literature review; (2) in-country surveys with farmers from different economic segments; and (3) in-country semi-structured interviews with key informants. The sampling methodology consisted of a multi-stage sampling approach, beginning with purposive sampling of districts followed by populations of subsistence to fully commercial farmers in target sub-counties and villages. Requisites for farmer participation in

[7] However, they did measure the poverty probability index (PPI) of respondents and results showed that the PPI did not significantly decrease the probability of participation in the majority of the aspects of the extension campaign (Tambo, et al. 2019).

the survey was that the farmer produced maize and that the farmer had experienced a FAW infestation in the past.

The districts of Masindi, Kiryandongo, and Iganga (Figure 2) were selected because of their levels of maize production, presence of small- and large-scale producers, and differential targeting for national FAW information campaigns in order to provide a representative picture of how farmers of different economic segments dealt with and were affected by this pest.8 Kiryandongo and Masindi were both districts targeted by the ICT-enabled information campaign led by CABI, whereas Iganga was not. This difference could allow for comparisons in information access between areas that were targeted by the information campaign and those that were not.

Figure 2. Map of the three surveyed districts in Uganda

A preliminary questionnaire was designed by first building a previous survey and study carried out by MAAIF and CABI that evaluated the effectiveness of that information campaign (Tambo, et al. 2019). It was further refined through semi-structured qualitative interviews with the district agriculture offices, 30 farmers in Masindi and Kiryandongo, and key informant interviews with the MAAIF and CABI staff. Based on these interviews, the preliminary questionnaire was tailored to this study's research objectives and digitized on the CommCare platform[9] to facilitate direct data collection and entry.

Once the questionnaire was digitized, eight Ugandan enumerators were recruited from the target districts, or at least had familiarity with the languages spoken in these districts. Ability to conduct the survey in local languages was critical because, while Luganda has become more commonly spoken throughout the country, it is not understood by all farmers. Each district in Uganda has its own language, while some districts such as Kiryandongo have multiple languages as many people were resettled there from other areas.

Selected enumerators were trained through a 3-day workshop on both the content and the digital data collection technology. Upon completion of the training, the enumerators were divided into two teams. One team, along with an international staff member, was assigned to Masindi district while the other team travelled with another international staff member to Iganga district.

[8] Surveyed sub counties or divisions in the three districts were as follows. Iganga: Nakalama, Nakigo, Nambale, Namungalwe and Nawandala; Kiryandongo: Mutunda, Kiryandongo, and Kigumba Tc; and Masindi: Kigulya Division, Pakanyi, Central Division and Nyangahya.
[9] For more information see: https://ics.crs.org/commcare

Randomly selected stratified sampling was not feasible given time constraints, so the study used a purposive stratified approach instead. The data collection team relied on local contact persons to select diverse male and female farmers in each district based on varying sizes of maize production and different wealth segments. These local contacts were community mobilizers who had a good general knowledge of farmers' socio-economic standing and land size and could be relied upon to provide reasonably stratified respondents. Women farmers selected for the final sample likely represented women-headed households, because they self-identified as directly managing maize production and likely would not have done so as part of a male-headed household.

Over two weeks of data collection, the Iganga team surveyed 151 respondents and the Masindi team surveyed 116 farmers, with the support of strong local contacts. The two teams then worked together to survey 142 respondents in Kiryandongo district. In total, 409 surveys were collected from farmers in the three districts, plus six interviews with larger farmers who cultivated at least 20 hectares of farmland. Surveys were carried out in individual settings so that the respondents' answers would not be influenced by others.

In addition, qualitative key informant interviews were conducted with 30 farmers in Masindi and Kiryandongo and 30 more farmers in Iganga. These farmer surveys were complemented with key informant interviews with MAAIF, NARO, CABI, the three district offices, agro-dealers, and maize processors.[10]

Survey and qualitative data were analyzed to identify key trends and farmers were disaggregated by economic segment using a wealth index. The wealth index was calculated from a weighted scale constructed based on the number of livestock (e.g., cattle, pigs, goats, sheep, and poultry) and selected household possessions (e.g., car, bicycles, radios, refrigerators, etc.). Each item is given a weight to reflect its monetary value (e.g., a car has a weight of 10 while a chicken has a weight of 0.2 while a cow has a weight of 5, and etc.), and the wealth index is the sum of the weighted value of all the items.

The following findings draw from the both the farmer surveys and qualitative interviews.

Results

Findings related to the overall situation of each district and socio-demographic information are first presented to provide a general characterization of the farmers and their context. Following this description of the context is a quantitative comparison of the districts based on results of the farmer survey. Results are organized and presented according to the study's Research Questions.

Respondent characteristics

Over 100 smallholder farmer households in each district plus six large maize growers in Masindi were interviewed (Table 1). Overall farm sizes were comparable across the three districts. Maize was

[10] These key informants include the district production and marketing officers who are directly in charge of the districts' responses to FAW, a MAAIF crop protection staff who is on The FAW National Task Force, the CABI staff who has been involved in CABI's extensive role in the regional responses to FAW outbreak, a NaCRRI scientist who leads much of the national-level research on FAW, NGO staff from NCBA-CLUSA and Farm Radio International, agro-dealers, maize processors and a maize seed production company.

an important crop in all three districts and was both a food and cash crop. Maize consumption was highest in Kiryandongo. Notable differences were that larger farms rented more land, especially in more remote areas where rent was cheaper, and home consumption of maize was higher in Kiryandongo by 10% to 20% relative to the other two districts.

Table 1. General characteristics of the survey sample in three districts and for large farms

	Masindi (n=116)	Kiryandongo (n=142)	Iganga (n=151)	Large farms (n=6)
Overall farm size (hectare)	1.8	1.7	1.6	31.3
Farmer experience producing maize (years)	13.8	17.0	17.5	22.1
Maize allocated for home consumption (%)	24.4	44.4	34.6	9.2
Maize land owned by farmer (%)	64.4	65.0	87.3	44.1
Avg distance to market (km)	7.5	5.2	4.0	12.9
Wealth index (#)	18.4	16.1	19.8	135.0

Table 2. Wealth index and number of respondents, by economic segment

	Segment 1	Segment 2	Segment 3	Segment 4	Large farms
Wealth index	Below 6.8	6.8 – 13.2	13.2 – 23.3	Above 23.5	35.6 – 250
Respondents (number)	102	102	102	103	6

Farmer respondents were also grouped by wealth index, with scores ranging from 0.06 to 279 among the 409 smallholder respondents. For ease of data presentation, the 409 respondents were divided into quartiles, each consisting of 102 respondents except for Segment 4 which contains 103 respondents (Table 2). In terms of wealth, Kiryandongo farmers scored lowest among the three districts (Table 1). There was also a direct positive correlation between men and wealth levels whereas there was an inverse relation between numbers of women within each of wealth segments, indicating that women (who were likely head of households) were poorer than men (Figure 3) among respondents surveyed.

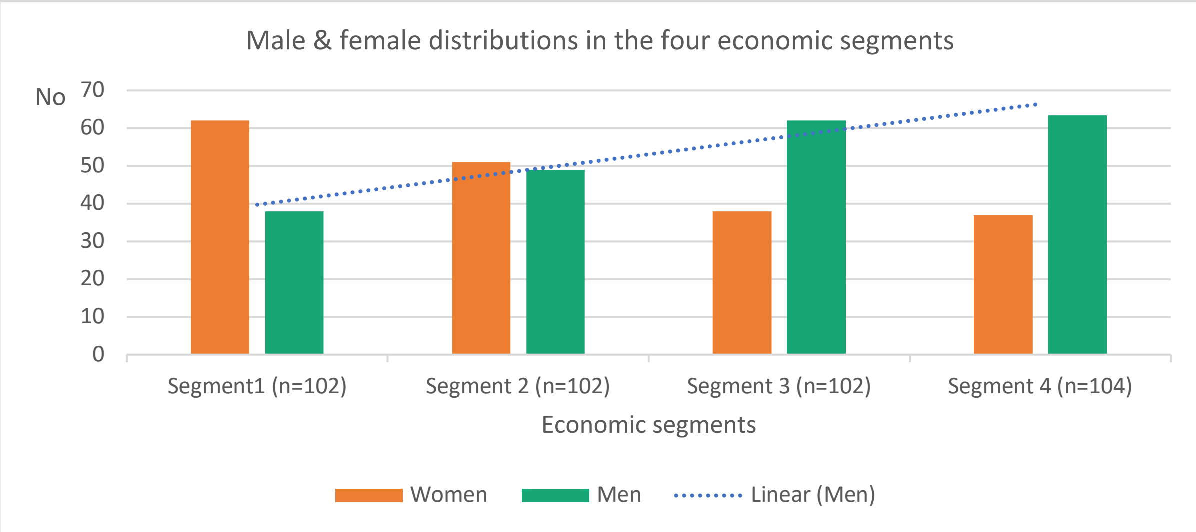


Figure 3. Number of males and females in each economic segment

RQ 1: Where do farmers from different economic segments access FAW information?

Information channels

Uganda's information campaign provided farmers several possible channels for FAW management guidance. Overall, the most common sources of information used by farmers to learn and act on FAW control methods were through neighbors and friends, extension workers and farmers groups.

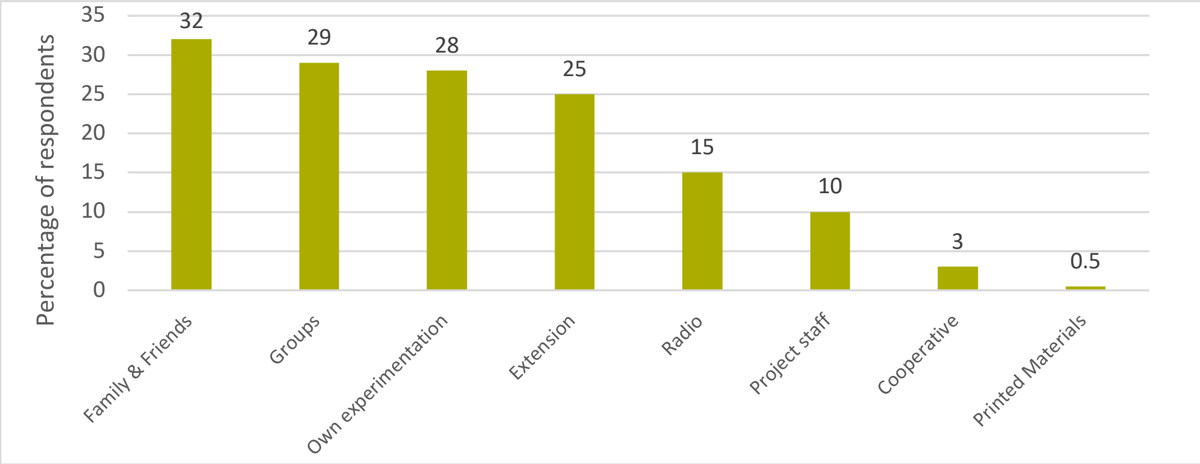
However, high numbers of respondents also accessed information directly through extension agents, either individually or through farmer groups. This result showed that the National Task Force efforts, which focused on extension services and radio, proved to be an extremely effective means of sharing information.

The most common information sources on FAW were friends and neighbors, extension agents, and farmer groups. Media channels such as social media, SMS, IVR calling, and printed materials had very limited use by surveyed farmers.

In contrast, very few farmers accessed information on FAW through internet, SMS, or social media, and those that did had higher education levels. Other information sharing channels, such as billboards, printed materials, and call centers were not commonly mentioned by farmers as key sources of information.

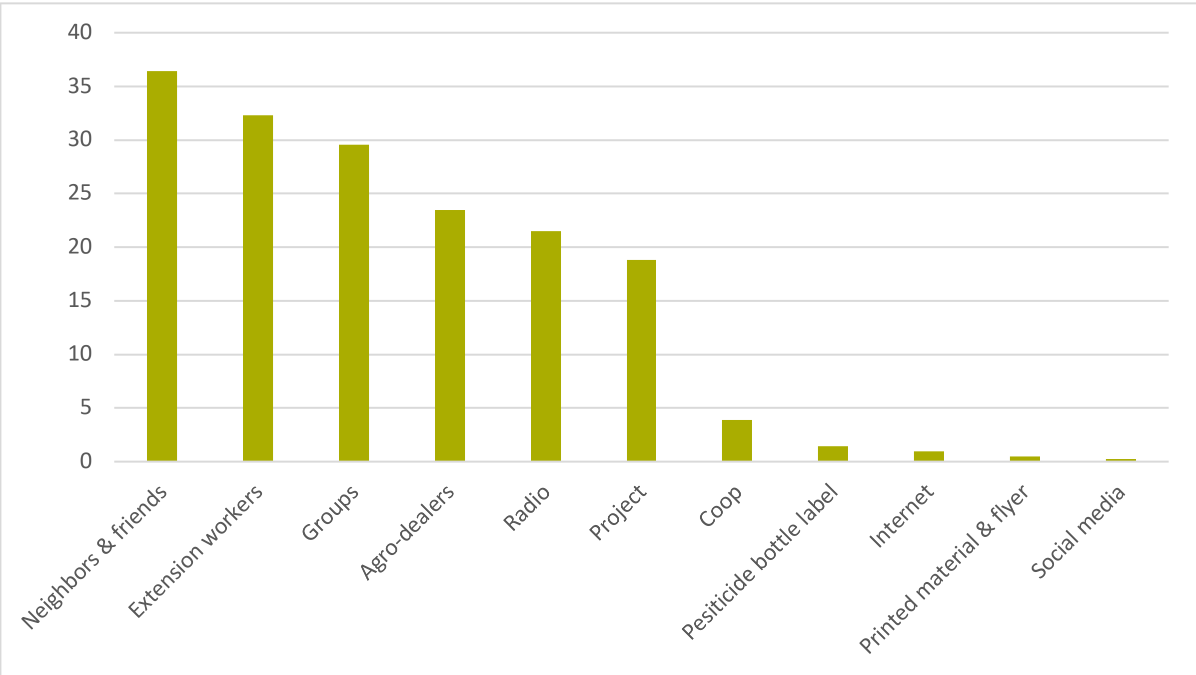
These trends were clearly reflected in the data related to non-chemical IPM information. According to this survey, farmers learned how to identify and monitor FAW in their fields through a combination of friends and neighbors (32%), farmers groups (29%), and extension agents (25%). For non-chemical control IPM practices, many farmers also relied upon testing ideas themselves through their own experimentation (Figure 4). The next most important level of information access was through radio broadcasts (14%) and projects (10%).

Figure 4. Sources of information for non-chemical IPM practices



Similar trends were found with chemical control options. The sources of information used by most farmers to learn about use of chemical pesticides were again through local social networks such as family, friends, and neighboring farmers (Figure 5). Interestingly, over 30% of respondents also accessed information on chemical pesticides directly through extension agents, who generally engage farmers through groups, agro-dealers, and agricultural projects.

Figure 5. Sources of information for how to apply chemical pesticides



Trends related to chemical control methods are particularly valuable because they represent not only awareness of the approach, but a behavior change for Ugandan farmers. Prior to the arrival of FAW, farmers would not likely have used chemical control methods for their maize crops. Hence, the use of chemical pesticides was a new production strategy for farmers producing maize in Uganda. The fact that approximately 70 % of farmers were using chemical methods to control FAW within two growing seasons of its discovery, indicates the severity of the FAW on maize production in Uganda but also the effectiveness of the MAAIF Task Force's FAW information campaign in changing farmer habits.

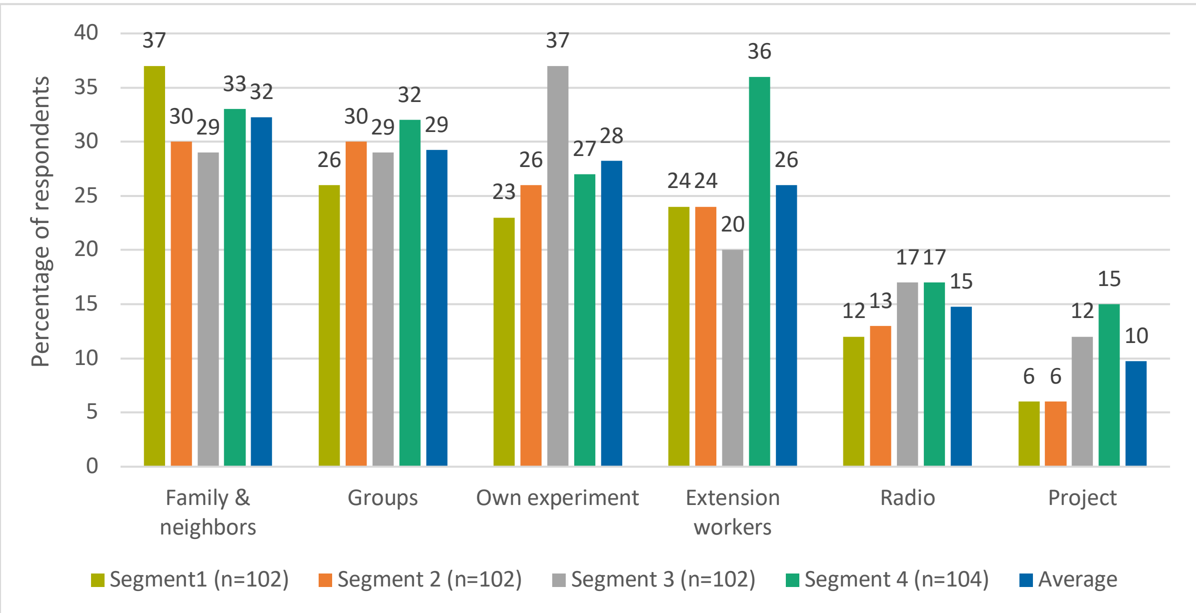
Approximately 70% of farmers were using chemical control methods to manage FAW, indicating the effectiveness of the MAAIF Task Force's FAW information campaign in changing farmer habits.

Wealth and information access

Wealth was found to be a key determinant for information sources. More affluent farmers accessed information through a broader range of sources and had better access to extension agents. Low-income farmers accessed fewer information sources and most relied upon secondhand information through their farmer groups and family networks. Large farms mainly relied on radio (67%), followed by agro-dealers (33%), and friends and neighbors (33%) for information.

The same trends are seen for non-chemical IPM and chemical control approaches. As farmers became more affluent, their information sources shifted from family and neighbors toward groups, extension workers, radio, and projects (Figure 6). Farmers also tended to learn from their own experiments at lower to moderate wealth levels, and less so at higher wealth levels.

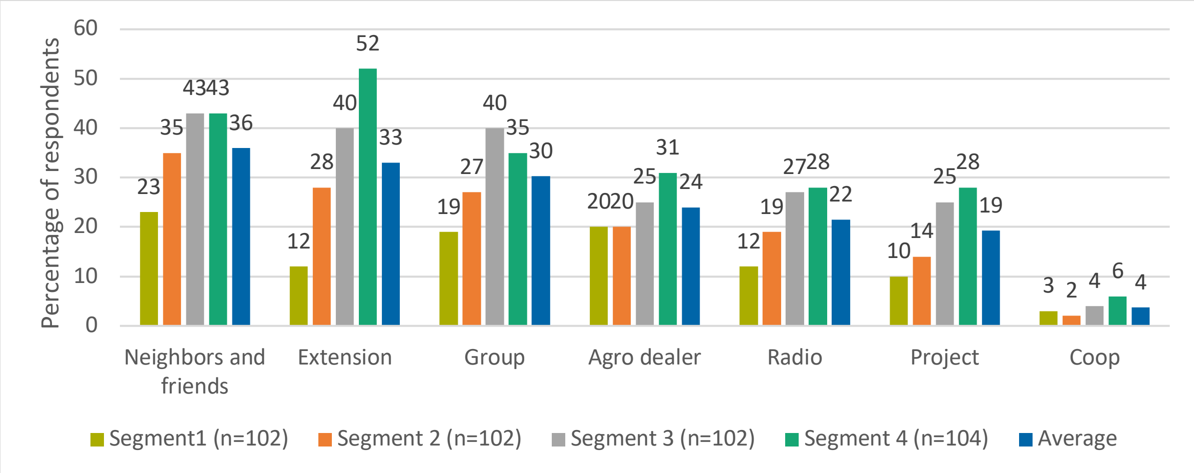
Figure 6. Sources of information for non-chemical IPM practices, by economic segment



When reviewing where farmers from different economic segments learned about chemical pesticides, the data show that low-income farmers were again more reliant on social networks (i.e. neighbors and friends) whereas more affluent groups accessed most information from extension workers (Figure 7). The access to extension agents by the high-income farmers is an important finding as this highlights that low-income farmers may face barriers and are clearly accessing less information from fewer sources.

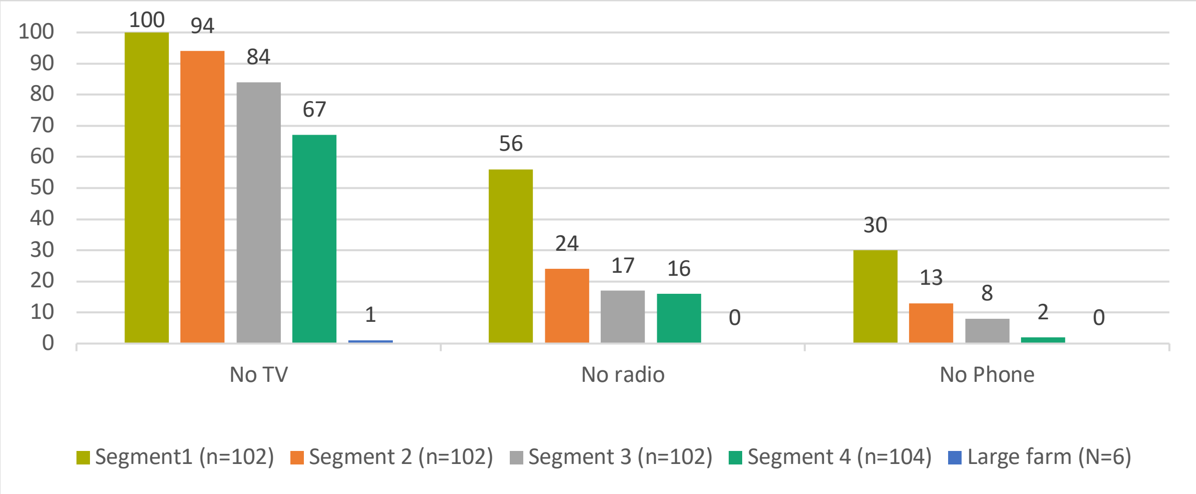
Wealthier farmers accessed FAW information through both extension agents and informal channels, whereas low-income farmers accessed information primarily through informal channels such as neighbors and friends. This could mean they are not in groups supported by extensions agents.

Figure 7. Sources of information for how to apply pesticides, by economic segment



ICT approaches also seemed affected by wealth, with wealth positively related to ownership of a television, radio, or phone (Figure 8). The reason that television talk shows or SMS messaging were not commonly accessed could therefore be attributed to the lack of means to access this type of information. Many low-income farmers do not own radios, although they can access radios. Phone ownership in Uganda is high but many farmers are not skilled in texting with phones and televised shows may not be very effective as few farmers own or have access to televisions.

Figure 8. Number of respondents who do not own a TV, radio, or phone, by economic segment

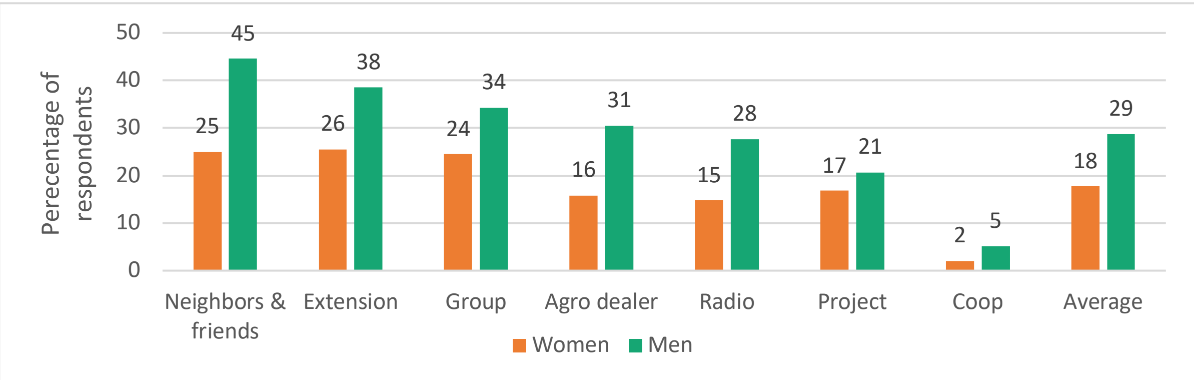


In addition to the lack of access, language barriers could pose a constraint, especially for low-income farmers and those with lower literacy levels, with many speaking only a local dialect. With information available only in major languages, many of these farmers relied on neighbors and friends, groups, and extension for information access. Reliance on informal channels for information may mean that not all messages are communicated effectively or efficiently, affecting FAW management decisions.

Gender and information access

Analysis across gender revealed that women had less access to information than men. This difference is clearly seen in access levels for men and women on chemical pesticide use (Figure 9). These access issues may have been compounded by lower wealth among women as well as other ICT-related factors not explored in this study.

Figure 9. Sources of information for how to apply chemical pesticides, by gender

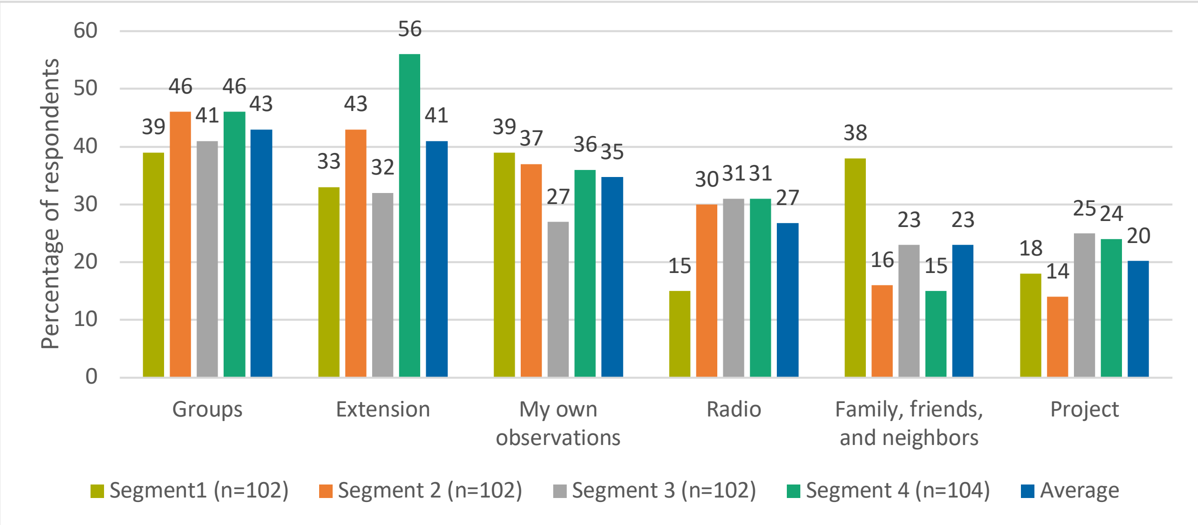


Information preferences

While actual information channels are crucial to understanding how Ugandan farmers learn about FAW management, farmers' information preferences also provide insight into how best to reach farmers with guidance that meets their needs. Wealthier farmers preferred to access information directly from extension services (Figure 10), while low-income farmers preferred to gather information from farmer groups, friends, and neighbors. Notably, farmers who preferred groups also mentioned that extension workers were often invited to their meetings to share FAW information. However, many low-income farmers indicated that they only received information through their social networks. This may be a concern because they are not in groups, or their groups are not being well serviced through the extension service.

All wealth groups also made decisions based on their own field tests. Projects were not commonly mentioned as an avenue for obtaining information.

Figure 10. Preferred sources of information, by economic segment



Information imparted by extension and channeled through groups provided the most accessible and trustworthy avenue for farmers to receive and share information.

When asked why farmers preferred certain sources, the majority responded that accessibility was most important, but that trustworthiness was also important. Farmers preferred to access information from the group, where members may be able to convey information in a more easily understood way. It can also be argued that extension workers may be the most trustworthy source of information, but they were not accessible. The best modality seems to be that trustworthy information is imparted to the group by the extension service, allowing farmers who belong to the group to gain information from the most accessible place and from the most trustworthy source.

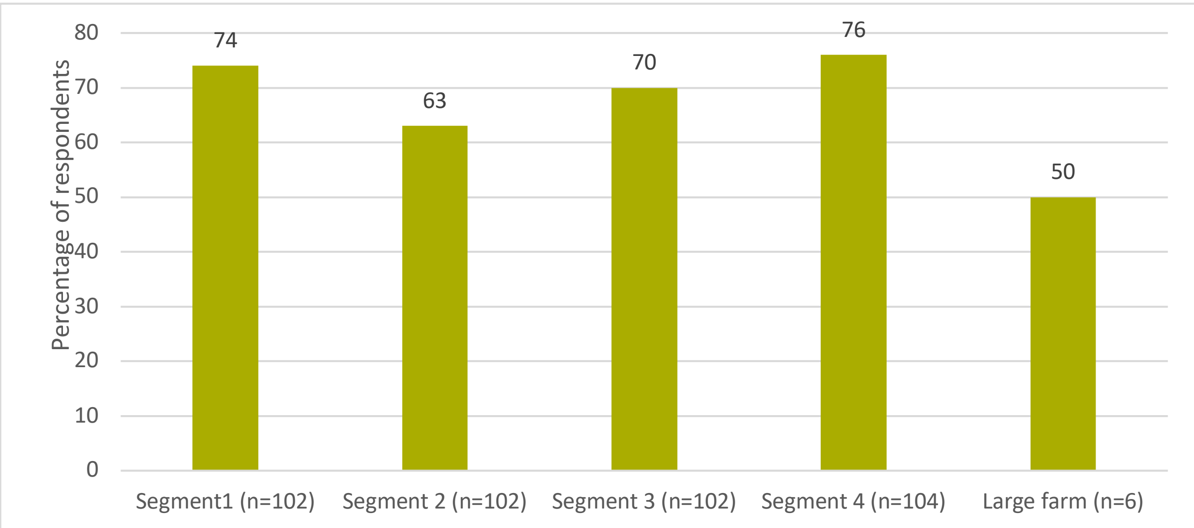
However, despite these preferences the economically disaggregated data indicated that low-income farmers mainly relied on neighbors and friends for information on FAW control while the more affluent farmers had better access to the most trusted sources being extension services and groups for information. The same difference could also be applied to women and men, as women farmers were poorer than the male farmers and therefore fewer options for accessing information. This again emphasizes the need for poorer farmers to have better access to groups to match their preferences.

RQ 2: What management practices did farmers adopt based on the FAW information they received?

Non-chemical IPM practices

Non-chemical Integrated Pest Management approaches, which in this study refers to cultural, physical, and mechanical prevention and control practices, were central to MAAIF's FAW management strategy. The initial non-chemical IPM practice that most farmers seem to have learned quickly is the ability to identify FAW and then apply some level of control. On average, 71% of farmers used some form of these non-chemical control IPM methods to control FAW, and they were equally used by farmers across the different economic segments (Figure 11).

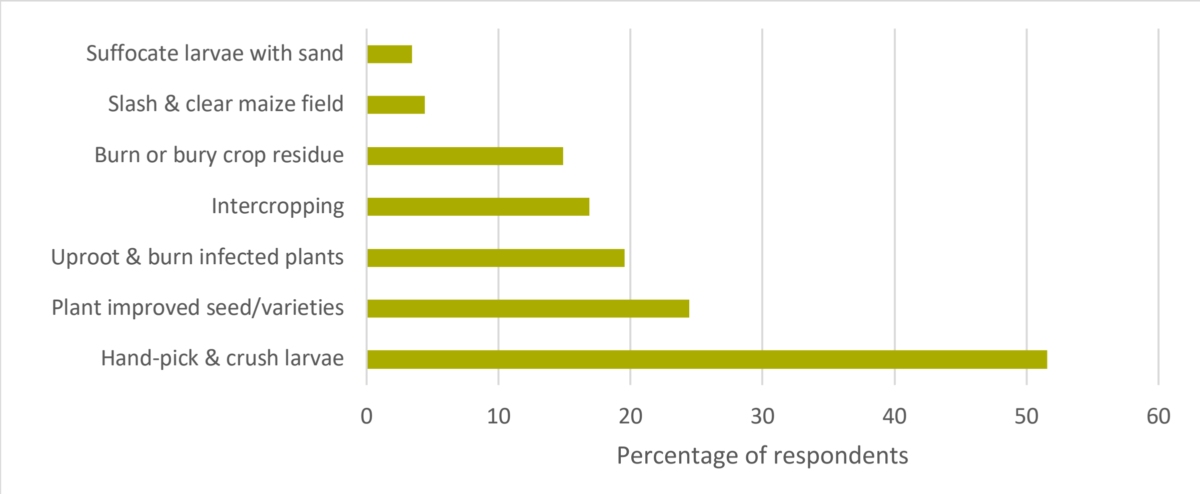
Figure 11. Use of non-chemical control IPM methods, by economic segment



Post FAW identification, the two most commonly used non-chemical control IPM methods to control FAW were (1) hand picking and crushing the larvae when infection was lower than 20%; and (2) use of quality seed of improved varieties (Figure 12). Other than these two approaches, less than 25% of respondents employed any other recommended methods. The top five applied practices shown in Figure 12 were recommended by the MAAIF Task Force, while the two least applied methods (slash and clear maize fields; suffocating larvae with sand) were methods adopted by farmers based on their own knowledge and experimentation. These methods were used across all farmer segments. Additional non-chemical control practices are categorized as other Good Agricultural Practices and presented later in this section.

When respondents indicated improved seeds/varieties, the preferred maize varieties were Longe 5, 6H, and 10H; Bazooka; and Kayongo. Varieties specifically bred for FAW tolerance or resistance are not yet commercially available in Uganda.

Figure 12. Use of specified IPM methods to control FAW



Chemical pesticides

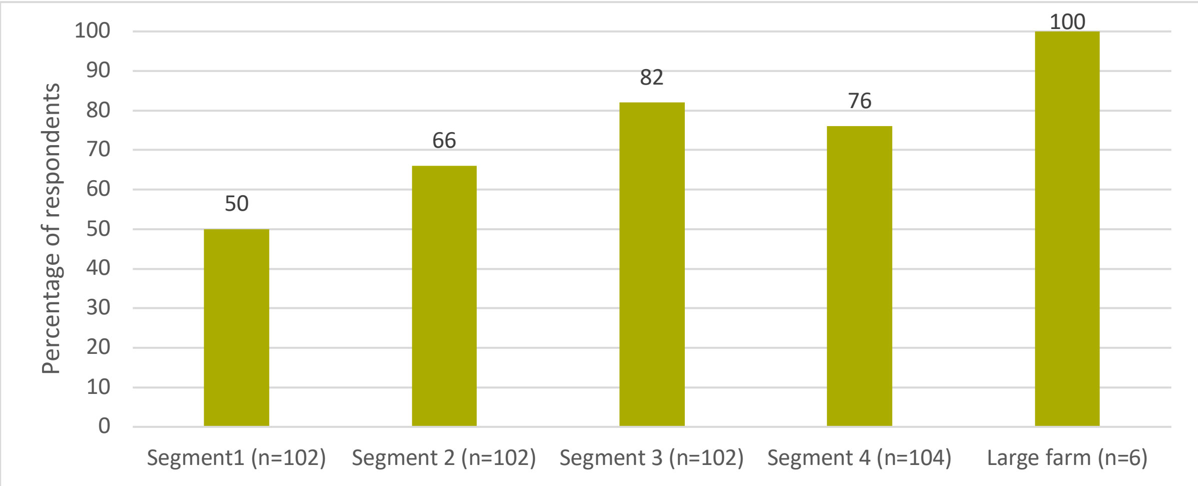
> *The FAW awareness and control campaign was extremely effective in supporting a major transition to chemical FAW control by farmers involved in maize farming.*

Perhaps the most important FAW management approach promoted by the MAAIF Task Force was for farmers to use chemical pesticides to control FAW infestations that affected more than 20% of the crop. The pesticide recommendations printed on the official FAW information flyers included two formulations for products with different active ingredients, "Striker" and "Roket," with only the general methods of spraying (Figure 1).11 Initially, MAAIF recommended those two trade names along with Dudu fenos, although MAAIF later released a longer list of recommended pesticides, many of which had the same active ingredients as the previous products (MAAIF 2018). These recommendations were backstopped by investments made by MAAIF to distribute Roket and Striker pesticides to selected farmers in the districts, both to control the FAW and to provide chemicals for demonstrations.

Photo 2. An agro-input shop owner and commercial maize farmer in Masindi Town, Uganda discusses his role in educating farmers about FAW control. Photo credit: Sarah Page for CRS

While most farmers already had a basic understanding about the importance of IPM and GAPs, use of chemical pesticides for growing maize was largely new strategy for smallholder maize producers in Uganda. Despite this being a notable change in production which incurred new costs, 67% of smallholders and 100% of the large farms indicated they had used chemical pesticides to manage FAW (Figure 13). These results are in the range found by CABI among smallholders who participated in the ICT-enabled information campaign and those who did not at 76% and 55%, respectively (Tambo, et al. 2019). Based on these results, the FAW awareness and control campaign was extremely effective in supporting a major transition to chemical FAW control by farmers involved in maize farming.

Figure 13. Use of chemical pesticides to control FAW, by economic segment



Trends also appear based on wealth, with wealthier farmers using pesticides compared with poorer farmers. Geography also influenced pesticide use, as more pesticide was used in Masindi (86%) and Iganga (80%) compared with Kiryandongo (38%). The lower rate in Kiryandongo may have been because they were less informed due to a shortage of district extension personnel, input supply constraints being located farther from major markets and roads, or that farmers there have fewer economic resources to purchase chemical pesticides (see Table 1).

Pesticide resistance and farmer experimentation

As noted, MAAIF recommended Roket and Striker pesticides for controlling FAW in its initial guidance. The survey found that 66% of respondents used the proposed chemical pesticides, while 34% of smallholder farmers and 57% of the large farmers used alternative pesticides[12] or mixed pesticides with Roket and Striker. These results are likely due to the fact that the Task Force campaign first recommended using only one pesticide per season in 2017, but later provided updated information which suggested that farmers should use different pesticides with different modes of action each season to avoid the build-up of resistance (The Independent 2019).

[12] Alternative pesticides included Ambush, Anti killer, Araphose, Chilobenzo, Clorobenzol, Cyperlenger, Cypermethrin, Dudu Cypermethrin, Dudu ethoate, Dudu feno, Dudu force, Dudu acemetic, Lara force, Lava, Profecron, Super grow, Tafgour

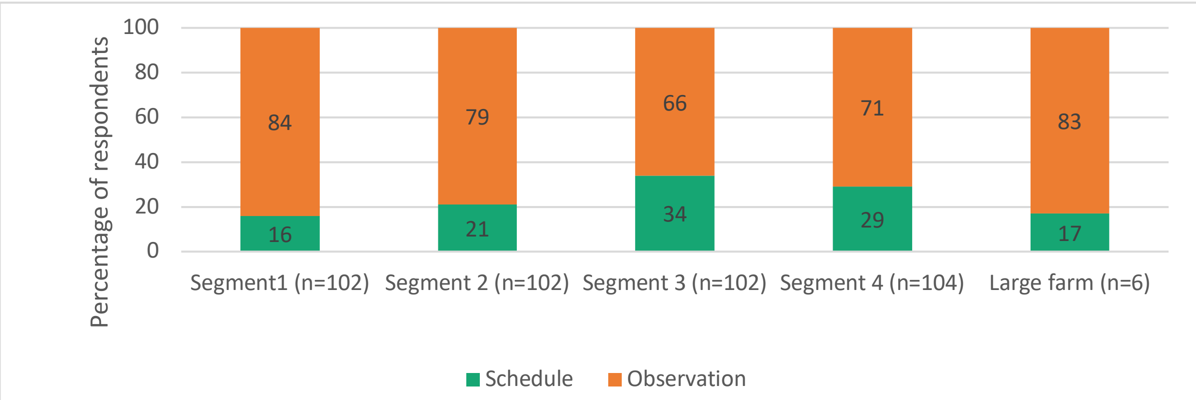
Due to this revised guidance or simply due to experimentation, farmers used a range of different pesticides and mixed chemicals in the hope of generating more effective combinations. This use of "cocktails" is a commonly observed within farming communities, as farmers seek ever more potent formulations to control a target pest. Masindi and Iganga district officers and farmers mentioned experimenting with different pesticides to control FAW as the outbreak progressed. Some farmers stated that Roket and Striker were not the most effective pesticides, while others believed that they lost their effectiveness against FAW over time. Potential resistance effects of spray regimes or possible introduction of resistant individuals into the population may require further investigation.

Treatment schedules and timing

As part of its broader guidance, the National Task Force also recommended that farmers follow a time schedule and start spraying one, two, or three weeks after larvae emergence, [13] and follow the same schedule until tasseling. The schedule aims to help farmers spray when the larvae/caterpillars are most vulnerable. Once they bore into the plant, they are difficult to reach and thus control.

On average, only 24% of respondent farmers sprayed on a fixed time schedule as recommended (Figure 14). Nevertheless, most farmers (76%) sprayed when the pest was observed in order to avoid spraying too soon or too late.

Figure 14. Use of schedule or observation to determine spraying, by economic segment



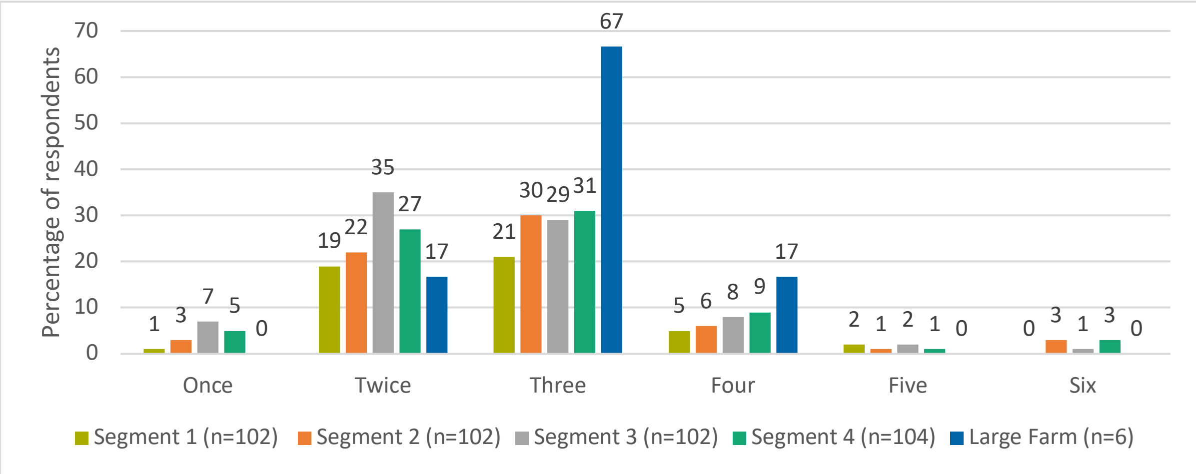
> *There was a direct relationship between wealth and chemical pesticide use. Men used chemical pesticides more often than women, likely related to higher wealth index scores.*

The data did show that farmers who sprayed were likely to follow the MAAIF guidance and spray three times (Figure 15). However, there was a broad range of spraying rates and many farmers sprayed once, twice, or four times. For farmers who only sprayed once, financial constraints or that they were too late in starting to spray were likely causes. Indeed, the data shows that while the recommendation was three sprays, poorer farmers tended to under spray. In contrast, wealthier segments tended to be spraying more than three times, perhaps because of thinking that more spraying would be

[13] There was no consensus among farmers whether it was one, or two, or three weeks after germination, which indicated farmers did not understand a uniformed or clear message on this.

even more helpful in controlling FAW, due to staggered planting dates of the crop, or other factors. Large farms mainly sprayed three times in accordance with the recommendations.

Figure 15. Number of chemical pesticide applications per season, by economic segment



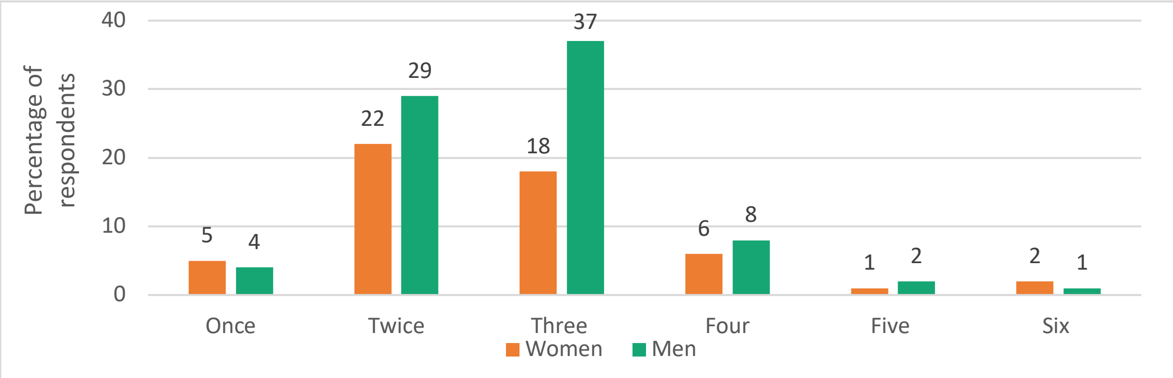
While farmers may not follow all recommendations related to chemical pesticide application, they appeared to follow instructions that were not dependent on their financial capacities. Nearly 100% of farmers adhered to the recommended time of day to spray, which was in the morning and afternoon (Table 3). The majority (71%) also sprayed correctly with the nozzle targeted on the plant whorl. Wealth did not seem to affect these trends. These practices are clearly stated in the flyer and are easy to follow as they are not cash dependent. This suggests that farmers are receiving messaging around use of chemical pesticides for FAW control but are making management decisions based on their financial capacities.

Table 3. Time of day when farmers spray pesticides

SPRAY TIMING		
Morning	Afternoon	Random
85%	11%	4%

Gender was one factor that did influence chemical usage. Among the respondents, 54% of women and 81% of men used chemical pesticides (Figure 16). A much higher percentage of men sprayed three times while most women only sprayed twice. The relationships between gender and wealth again emerges here, since women had a lower average wealth index and may have sprayed less due to lack of access to information and/or lack of cash for the chemicals or labor to spray. There are also likely other factors contributing to lower incidence of spraying (e.g. health concerns, gender norms, cultural division of labor, decision-making power) that this study did not explore.

Figure 16. Number of chemical pesticide applications per season, by gender



Dosage

Guidelines on pesticide dosage was not well-communicated through the information posters released by MAAIF and the Task Force. It simply stated that farmers use 20–50 ml per 20 liters of water for pesticides with the formulation of Profenos 40% + Cypermethrin (such as Roket) and 10–20 ml for Thiamethoxam 141 g/l + Lambda-Cyhalothrin 106g/l (such as Striker). Farmers were advised that the dose rate should increase between the first and the second and third sprays to kill larvae as they matured (i.e. more active ingredient for more mature larvae). However, specific information about the amount by which it should increase was not given. Also, in cases where farmers were using different types of chemicals to avoid resistance, clear guidance about how to rotate chemical controls by using different formulations and different active ingredients was lacking.

As a result, dosage varied widely during first sprays (Figure 17) and subsequent sprays (Figure 18). Over-dosing potentially creates concerns about safety to farmers. Under-dosing was more common than over-dosing and it was more prevalent among poorer farmers, either due to a lack of cash, a lack of clear guidelines, or both. This type of behavior is problematic and can lead to insecticide-resistance, although many farmers may not be aware why under-dosing is as bad as over-dosing.

Figure 17. Pesticide dose used for the first pesticide application, by economic segment

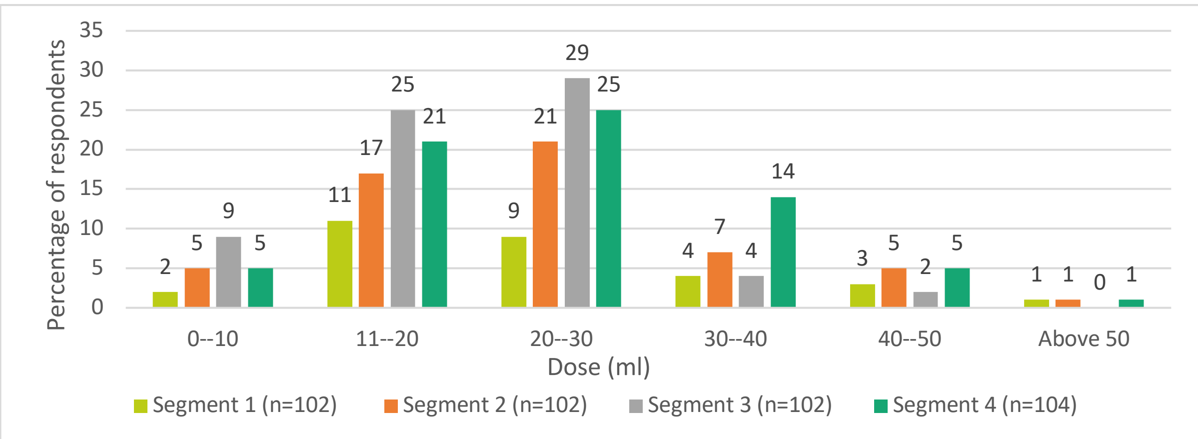
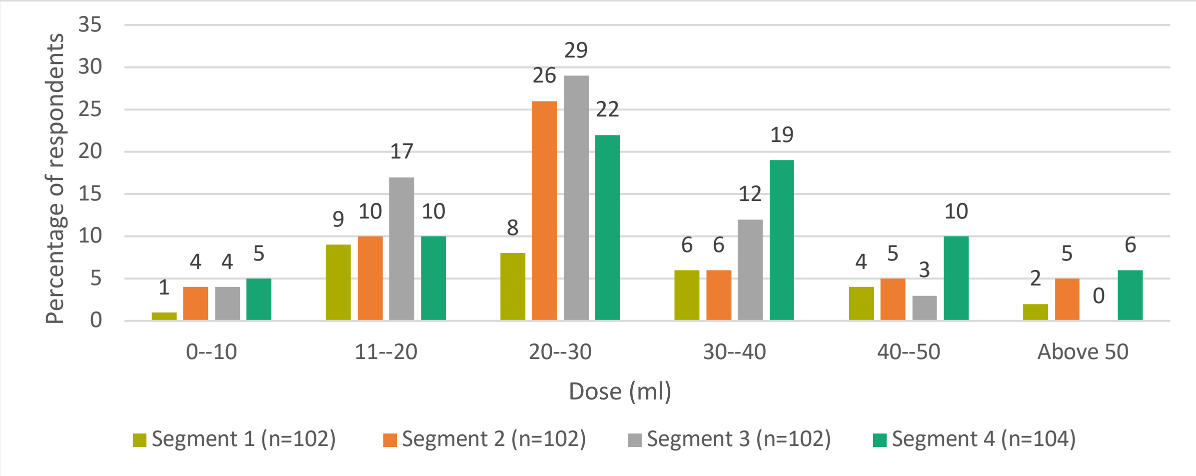


Figure 18. Pesticide dose used for subsequent applications, by economic segment



Homemade FAW control products

In addition to commercial chemical pesticides, many farmers also tested and used various homemade products, mixtures, and sprays to control FAW. These products were made from locally available materials and referred to as “biological products or biological sprays” in Uganda although they did not contain biological control agents. Because they were not scientifically proven to be effective, these sprays were not approved or promoted by MAAIF to control FAW, and extension workers did not provide information on these alternative products.

Table 4. Use of various homemade products

Ash	9.8%
Ash + pepper + sand	5.4%
Pepper	2.2%
Soap + detergent	0.7%
Neem leaves	0.2%
Tobacco + soap	0.2%
TOTAL	17.8%

Overall, only 17.8% farmers used some form of homemade product to control FAW. The most used local product to control FAW was ash (9.8%), followed by the combination of ash, pepper, and sand (5.4%) (Table 4). In general, these products were applied to the whorl to kill or suffocate the caterpillars that burrowed into the stem. Use of these products cut across wealth levels and there was no discernible trend based on economic level, as farmers in all segments tested these methods.

Farmers cited both advantages and disadvantages to these homemade products. The advantage of these products was they were low cost when made from readily available products and farmers could use these methods on other crops. Farmers also mentioned several constraints in the use of these products, which included:

1. **Labor Costs:** Although the materials may have been free, application of these methods required three times the labor compared with chemical pesticides.
2. **Scalability:** The methods were not scalable to areas larger than one hectare, especially those that required high quantities of ash.
3. **Human health risks:** Some hot pepper-based solutions were said to be so potent that it was hard on the respiratory system.

The main reason that farmers did not use homemade sprays more widely was due to lack of information (68%) or the high labor demand (15%). Some farmers also described how these homemade sprays could be used as a supplement to chemical spraying and suggested combining the two for different stages of the larvae growth. The common belief was that the biological sprays were more effective on full-grown larvae while chemical pesticides were most effective on immature larvae. However, the survey results showed that only 7% of farmers combined chemical and homemade sprays, and this was mainly due to having insufficient funds to purchase chemical pesticides.

Other Good Agricultural Practices

Beyond management practices that directly targeted FAW, the MAAIF and Task Force also placed considerable emphasis on general good crop management practices that contribute to the overall IPM approach through increasing plant health and are practices that farmers can and are already applying. These GAP methods contribute to improved productivity but also make crops more resistant to FAW damage. The key practices include:

- **Early planting:** Early land preparation allows farmers to be ready to plant at the onset of the rains. Early planting reduces the likelihood that female moths will deposit eggs on the maize and ensures that the crop has ample time to establish, increasing plant vigor and enabling the crop to better withstand pest infestations (FAO 2018). If maize is planted sufficiently early, losses caused by FAW can be limited to 20%, while late planting may lead to 50%+ losses. Early land preparation and planting is a commonly taught GAP, but to plant early for FAW control is a new and critical concept in Uganda.
- **Crop rotation:** FAW primarily attacks cereal and legume crops such as maize, rice, and sorghum. When maize is rotated with other crops such as soy or groundnuts, the rotation breaks the FAW's breeding cycle. Farmers have used this practice to control insects of other crops and were advised to also apply this method as a control against FAW.
- **Timely weeding:** This method promotes healthy crop growth, particularly during the early stage of the plant, which then leads to better resistance to FAW attacks.
- **Proper spacing:** Proper crop spacing helps to ensure that plants are healthier due to less competition for resources and are then better able to withstand damage from FAW. Despite this emphasis, most of the FAW control messages were focused on chemical pesticides while messaging around other IPM strategies including general GAPs was less developed. Consequently, farmers lacked knowledge of GAPs or understanding of how they related to FAW prevention and control, which is reflected in the data. More detailed information on these measures may have increased farmer adoption rates.

Though farmers indicated that early planting (70%) was the single most useful cultural practice to control FAW, large numbers of farmers were also effectively using weeding (86%) to control

FAW. Early planting (70%), proper spacing (66%), and crop rotation (61%) were practiced by comparable numbers of farmers. Similarly, the use of these GAPs was similar across all farmer wealth segments.

However, not all farmers followed the GAPs recommended by the MAAIF. Failing to plant early was mainly the result of unpredictable rains (19%), followed by not being able to finish manual plowing (8%). Sometimes farmers planted at the onset of the rains, only for the seeds to fail when the rains stopped. Other times, such as in March 2019, those who planted early got lower yields than those who planted late because it rained too much in the beginning of the rainy season. Early planters harvested on average 25 bags per hectare compared to 37-50 bags per hectare for those who planted late when the rains had subsided. While those who planted early usually got better yields, farmers' uncertainty led many to plant when the season came because no one could tell exactly when the right amount of rains would fall. While it is not possible to predict the rains in this changing climate, messages can focus on advising farmers to incorporate weather forecasting into their traditional knowledge of weather patterns and build competencies for climate risk management.

"In the past, when we were still young, seasons were so well organized we all knew to plant in early March, and it was always predictable. Now, some areas are drought and some too much rains. Now the global warming is causing the rains to be unpredictable, sometimes the rain is pretending to start and then it stops." -General Secretary of the Rural Agricultural and Cultural Association, Kawete Village, Iganga District

In terms of other GAPs, 19% of respondents indicating that they did not see the relevance of crop rotation for FAW control. For rotations, the most common reason cited for not planting other crops was that were not as profitable (9%) and that labor for weeding for these other crops was too high (2%).

19% respondents did not think crop rotation was important to control FAW.

Summary of management approaches

All four management approaches were practiced widely among the farmers surveyed. Each had strengths and weaknesses (Table 5), but all were useful in controlling FAW. Across all management approaches, labor and cost are two major constraints.

Table 5. Strengths and weaknesses of FAW control methods

Control Method	Strengths	Weaknesses
Chemical pesticides	Most effective when used correctly.	Costly, higher human and environmental health risks, need to follow guidelines precisely, and requires additional labor.
Non-chemical Integrated Pest Management	Lower human health and environmental risks. Applicable on any scale.	Time consuming, at times knowledge-intensive, labor intensive, improved seeds are expensive.
Other Good Agricultural Practices	Contribute to overall productivity and production as well as FAW control (win-win).	Each practice requires labor with associated costs. May not be economically feasible to implement all recommended GAPs.
Homemade products	Potentially less costly, good for small areas, likely to have lower human health and environmental risks. Perceived to be effective in controlling larger larvae.	Labor intensive, unproven, and can only be applied on areas less than 1 hectare.

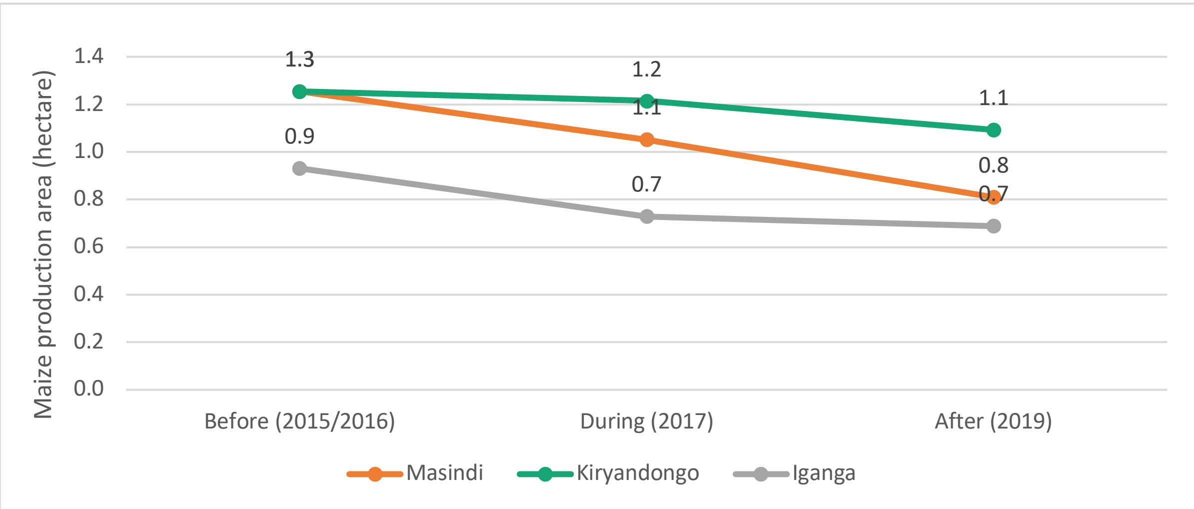
RQ 3: What are the results of farmers' actions to control FAW?

This section examines how farmers acted based on the information they had obtained from the various sources, and the outcomes of farmer actions to control FAW.

Impacts on production and yield

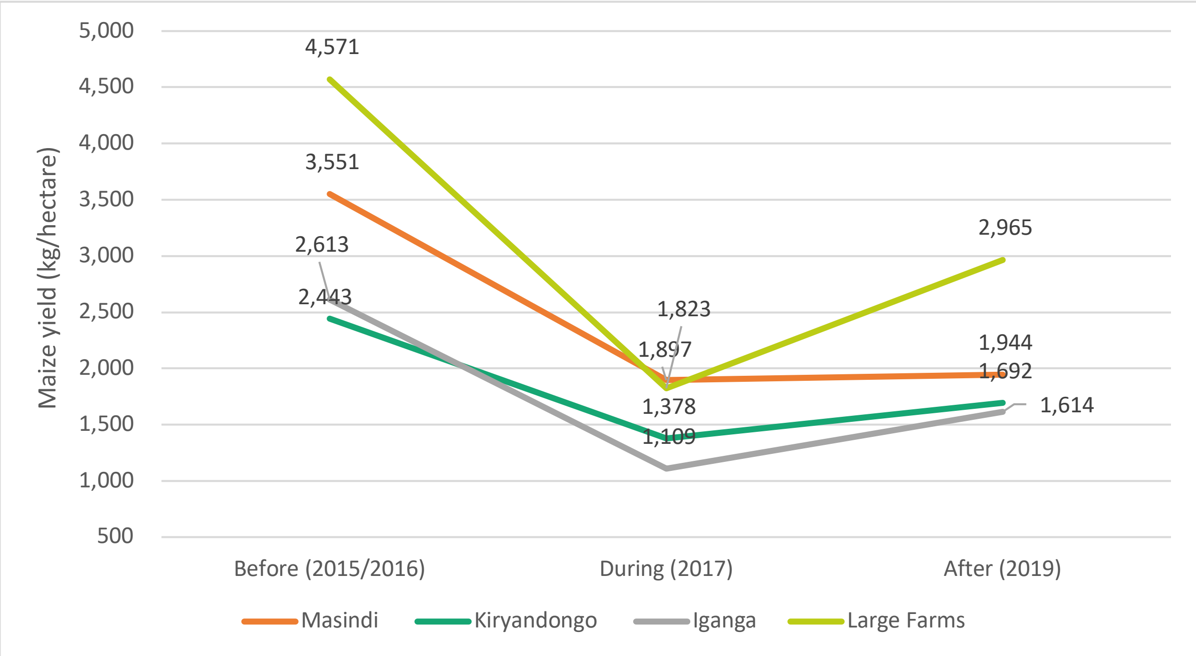
As farmers experienced FAW and took steps to manage the pest, different outcomes were reported in terms of their production and yield changes.

Figure 19. Maize production area before, during and after the 2017 FAW outbreak



Maize represented a major staple crop in all three districts surveyed. In fact, maize production accounted for nearly 80% of the total farmland in all three districts prior to the FAW infection (Figure 19). At the onset of the FAW outbreak and before any interventions were introduced, levels of maize production and area decreased substantially as farmers allocated land to other crops. The decrease was less in Kiryandongo because maize was a more important food crop compared with the other two districts.

Figure 20. Maize yields before, during, and after the 2017 FAW outbreak



The decrease in area planted in maize may be explained partly by the yield loss caused by FAW and the fact that yields have not yet fully recovered, despite the interventions. The data in Figure 20 show that yields were considerably higher before FAW and, and despite reductions in yield loss, yields remained low after management interventions were adopted. This was challenging for farmers who now had to invest additional cash to address FAW but still had considerably lower yields than before.

Other factors may also have contributed to yield losses, notably that the height of the FAW infestation also occurred during and following periods of severe drought. Additionally, the lower yields in Iganga were also partly caused by a local Striga outbreak caused by using pooled tractors infested with Striga seeds to plough farmers' fields. With Striga having spread throughout the district, measures are now being taken to address the Striga-related production issues as well.

Adoption rates of different FAW control approaches and yield implications

Farmers were presented with a range of options for controlling FAW, through the formal MAAIF/Task Force guidance, their social networks, and their own experimentation. As a result, different control approaches were adopted at different rates.

The data in Table 6 summarizes the adoption rate of all FAW control methods presented in the section above and compares them against the yields obtained by economic segment. There was a close relationship between the levels of adoption of FAW controlling measures and yield, although correlation figures could not be calculated due to the nature of the data.[14] Across the various segments, the data seem to indicate that good adherence to the use of chemical pesticides had the most effect on mitigating yield loss. Higher economic segments tended to adopt management approaches at higher levels and saw corresponding yield benefits. The large farms did not have the highest adoption rates of non-chemical IPM methods and general GAPs, but because they used quality seed and fertilizer and followed the guidelines of chemical pesticides most closely, they achieved yields much higher than all farmer segments.

Table 6. Adoption of FAW control methods and maize yield, by economic segment

	Segment 1 (n=102)	Segment 2 (n=102)	Segment 3 (n=102)	Segment 4 (n=104)	Large farm (n=6)
Non-chemical IPM methods	74%	63%	70%	76%	50%
Chemical pesticides	50%	66%	82%	76%	100%
Homemade products	10%	18%	24%	14%	17%
Early planting	69%	62%	79%	71%	50%
Timely weeding	87%	91%	86%	78%	67%
Proper Crop spacing	52%	66%	68%	79%	50%
Crop rotation	53%	60%	65%	64%	50%
Average level of adoption	**30%**	**42%**	**53%**	**45%**	**58%**
Yields (kg/ha)	**1,374**	**1,619**	**1,777**	**2,029**	**2,965**

Gender and yield implications

Gender again was a determinant in yields, with the overall gender disaggregated data (Table 7) showing that women had lower yields than men. This was probably a compound effect of several of the factors described in earlier sections that were not explicitly addressed by the survey. Potential factors could include lower access to information, less access to good land, lower wealth, lower levels of education, and less access to labor. All these factors could have contributed to the fact that women (and especially women-headed households) were less likely to practice the correct use of chemical pesticides, used lower dosage rates, and did not spray three times as recommended.

[14] Since all the explanatory variables here are binary data, a regression in this case would not provide the same robust analysis as it does with non-binary data.

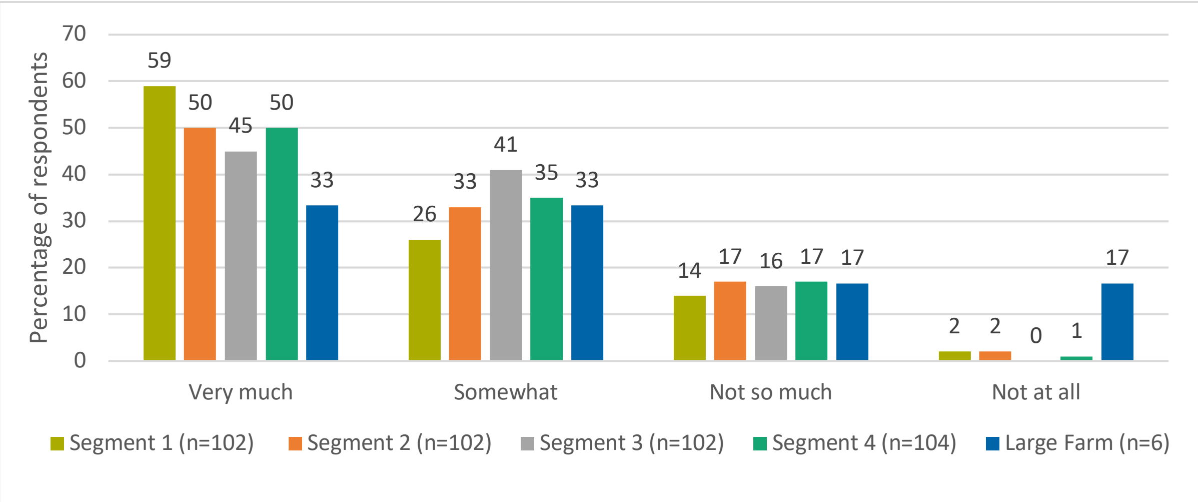
Table 7. Use of chemical pesticide and maize yield, by gender

	Women	Men
Spray chemical pesticides	54%	81%
Spray pesticides 3 times	18%	37%
Yield (kg/ha)	**1,562**	**2,249**

Farmer attitudes towards FAW

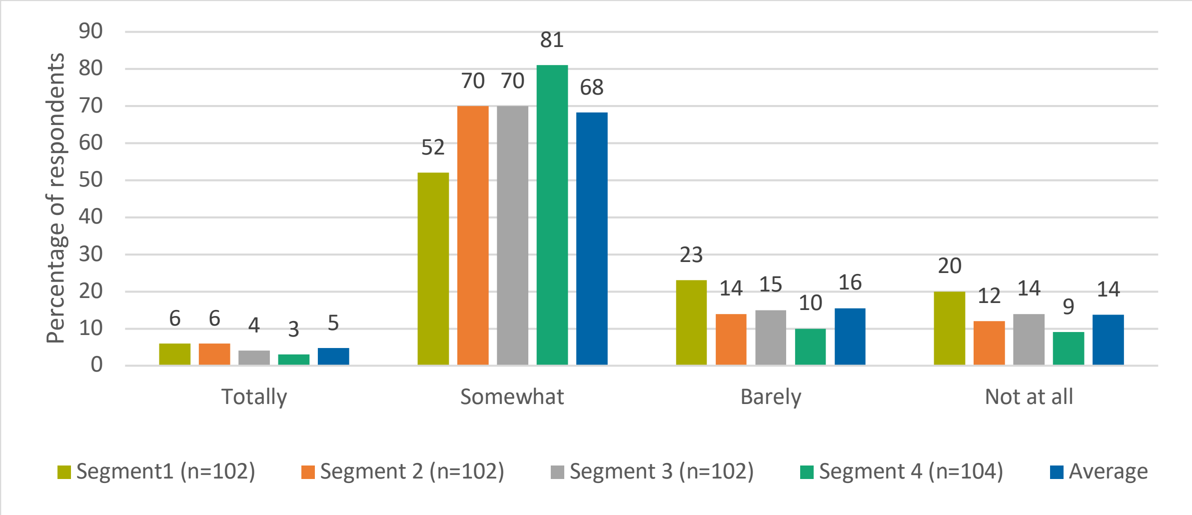
Since the onset of the FAW outbreak in 2017, farmers have recognized the threat posed by the pest and adopted FAW control measures designed to mitigate crop losses. These actions successfully resulted in reduced losses and a rebound in yields (Figure 19).

Figure 21. Extent to which FAW is perceived as a threat, by economic segment



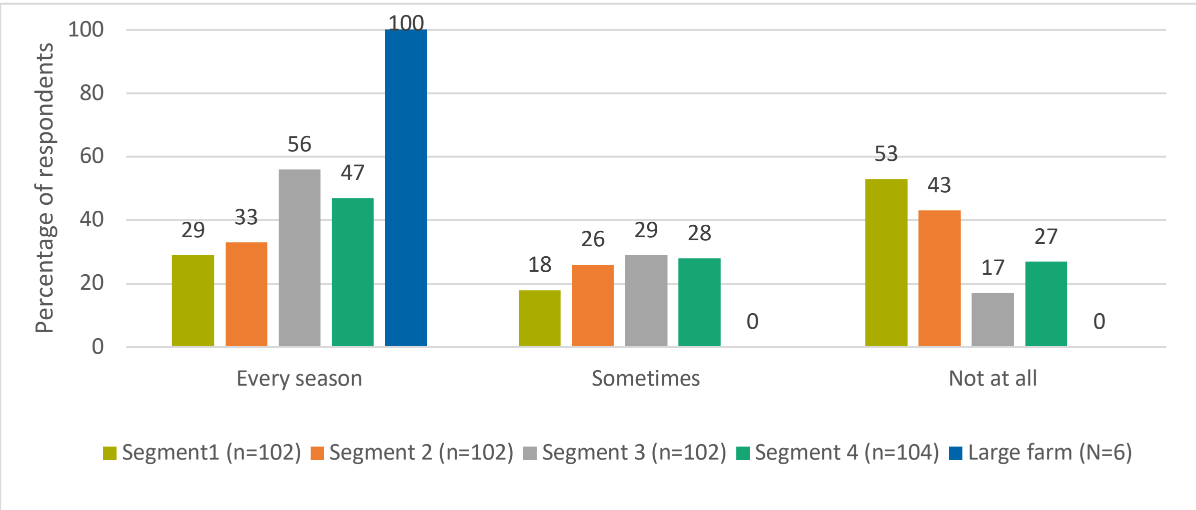
However, farmers across all economic segments still consider FAW a threat to their maize production (Figure 21). More than 51% of farmers described FAW as a serious threat, and 34% as somewhat of a threat. The poorest segments of farmers considered FAW a high threat, although even the large farms feel that FAW still posed a threat to their production. Despite the threat of FAW, there was some degree of confidence that farmers now know how to reduce its impact (Figure 22). There was also a positive correlation between wealth segments and confidence levels, with confidence tending to increase along with wealth. While Segment 1 farmers feel least confident, Segments 3 and 4 feel more confident in their ability to control FAW.

Figure 22. Level of confidence in ability to control FAW, by economic segment



This confidence is reflected in the preparations farmers are making for future growing periods. Given the high level of adoption farmers have made in use of chemical pesticides to control FAW, many also realized that they would need to invest in the full package of hybrid seed, fertilizer, and now chemical pesticide to achieve a reasonable maize yield. Some farmers were saving money to buy next season's chemical pesticides. As with the other trends, wealthier farmers were most able to save for following years. The large farms were 100% committed to saving for the following season, but fewer of the poorer farmers were able to save (Figure 23).

Figure 23. Frequency of saving for pesticide purchase, by economic segment



Despite the threat, the lack of confidence, and shortage of money, the majority of smallholder farmers across the economic segments planned to increase maize production (64%), or at least maintain the same level (31%), regardless of economic segment. This shows the value farmers place on maize for both food and cash.

Disaggregation by gender revealed that women and men had similar attitudes, confidence in being able to control the FAW, and future plans for maize production. The main differences was in preparing for future FAW control, with twice as many women (half of all questioned) indicating that they could not save to purchase next season's pesticides.

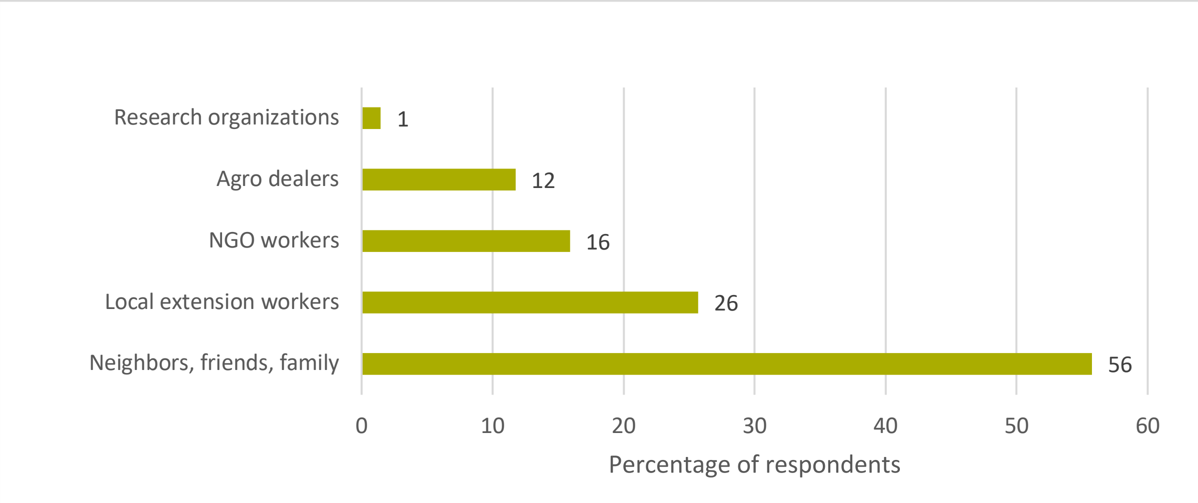
RQ 4: How do farmers of different economic segments share information, provide feedback, and request further information on FAW control?

This section examines (1) whether there were feedback loops in the information system that allowed farmers to learn and share their experiences on how best to control FAW, and (2) whether their ideas and learning could be used to influence future FAW programming and perhaps even affect policy. More precisely, this question explored farmers' ability to move from being simply recipients of knowledge to being able to share their own knowledge and innovation not only with their peers, but also to help make the research-extension-farmer system more dynamic and more demand-driven.

Feedback loops by type

The first step towards an effective agricultural information system is for farmers to share their feedback and learning with others. Indeed, 70% of respondents reported that they shared information on their experiences with others (Figure 24). The most common response was that farmers shared with neighbors, friends, and family (56%), followed by extension workers (26%).

Figure 24. Actors with whom respondents shared feedback



Of the 70% of farmers who provided feedback on their experiences, most of the feedback was shared in person (70%). Among ICT approaches, only radio (56%) was used to provide feedback with any consistency. There was very little interaction via digital systems such as SMS texting, and social media (Table 8). No respondents had used the Plantwise factsheet app to share feedback, although there was one respondent who had solicited information via the factsheet.

Table 8. Farmer use of radio and for learning and feedback

	Learning about chemical pesticides	Learning about non-chemical IPM	Providing Feedback	Soliciting Information	Total
Radio	22%	15%	8%	11%	56%
SMS/texting	0%	0%	2%	1.5%	3.5%
Social media	0%	0.2%	0.7%	0.7%	1.6%
Internet	1%	0%	0%	0%	1%
Plantwise	0%	0%	0%	0.2%	0.2%

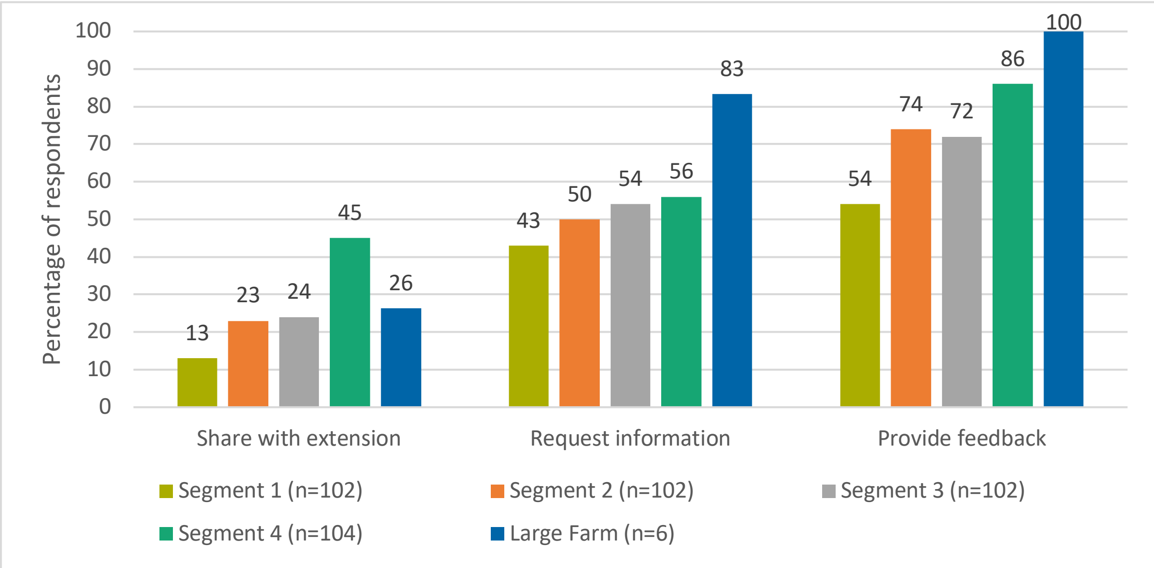
In addition to sharing feedback, 62% of farmers also asked questions and received additional information. Most of this was done through person-to-person communications with friends and neighbors. Most respondents found the responses to their inquiries very useful (52%) and at least somewhat useful (46%).

Feedback loops by economic segment

There was a clear effect of economic segments on farmers' ability and willingness to provide feedback and share learning with others (Figure 25). Few farmers in the lower wealth segments reported sharing with extension, possibly due to lack of direct access. The feedback loops appeared to be working better for the wealthier and larger farms, with wealthier farmers sharing feedback and requesting additional information from extension in much higher numbers. In contrast, poorer farmers tended to circulate information with their peers, indicating a trickle-down spread of information through social networks.

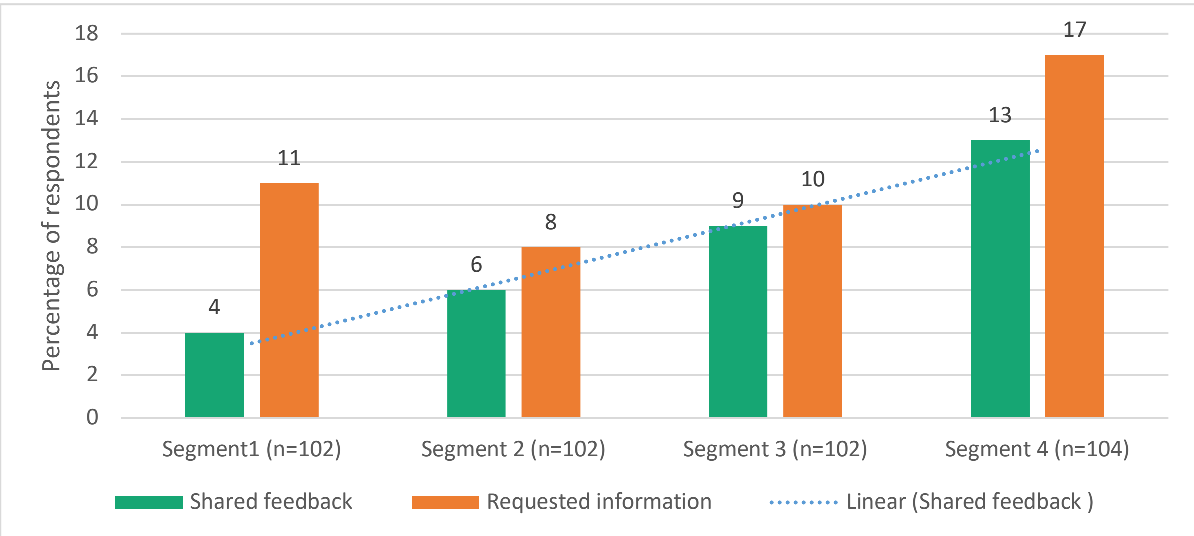
The feedback loops that did exist, however, appeared to more about responding to questions asked by farmers, rather than extension agents or research systematically receiving information, or learning from farmers which they could use and feed back into their systems. The inference was that a top down extension process appeared to be working in terms of verifying official information, but the learning system was not able to harvest information and accelerate innovation based on farmer-led feedback.

Figure 25. Occurrence of sharing feedback or requesting information, by economic segment



Similar trends were found with the use of ICTs, where there was a strong correlation between wealth and the use of radio (Figure 26). This trend coincided with the correlation between wealth and ownership of radios and phone noted in Figure 8 above, because ownership of both is needed to ask questions in radio feedback sessions, although radio listeners can benefit from responses to the questions raised by others.

Figure 26. Occurrence of sharing feedback and requesting more info through interactive radio programs, by economic segment



Conclusions

This study assessed how farmers learned from the Ugandan Ministry of Agriculture, Animal, and Industry's Fall Armyworm control campaign, what actions they took in response, how those actions affected their production outcomes, and how they in turn provided feedback to their local social networks and the larger agricultural information system. Findings identified successes and areas where improvement could be explored in combating FAW in Uganda.

Farmers prioritize accessibility and trustworthiness in sources of information

The overriding result from the analysis was that farmers received and preferred to receive information in ways that provided both access and trustworthiness. The data showed that social networks, direct interaction with an extension agent, or farmer groups were prioritized.

Media channels and ICTs showed far less impact that groups and social networks in spreading FAW information and affecting management behaviors. The consistent result from this survey was that poorer farmers, who make up the majority of farmers in Uganda, have challenges with accessing digital messaging and feedback systems such as SMS, IVR, and other social media channels to access, share, and request information. This result matched CABI's earlier study, which found that only 8% of the sample population was reached by SMS channels. Poor farmers may have lacked radio and phones, and also may not have understood how to access messages broadcast on social media or SMS, even if they were in local languages (Tambo, et al. 2019). This may be a result of lower digital literacy or simply a preference and trust for more familiar interactions when it comes to learning and decision making. Radio was the only channel which more than 20% farmers used, which again matched the finding from CABI (Tambo, et al. 2019).

Groups provide maximum value in information sharing

Throughout the survey, the value of groups emerged for both receiving and discussing information about FAW control. Data showed that farmers preferred to access information through in-person communication within their group. Information received through groups was also considered the most accessible and trustworthy, especially when groups receive information from extension services who provide this information to group members in person.

The data highlights the value of functional and inclusive groups in the farming community and how extension messaging is socialized through group meetings. Groups also appear to be effective in promoting demand-driven FAW control measures and fostering farmer-led innovation. This is a strong endorsement of the farmer organization approach, and gives agencies a data point for continuing to invest in the development of functional farmer groups who not only work together for financial gains but also work together as an effective means of learning, testing ideas, and sharing information within and beyond the group. Key to this effort, however, is to ensure that farmers of all economic segments have access to groups and gain from their knowledge-sharing benefits.

Furthermore, extension agents were also able to multiply their training abilities by providing demonstrations to groups and group leaders, who continued to socialize the information. Farmers also engaged in their own experimentation and it was through this information flow or trickle down that poorer farmers received information.

MAAIF's FAW information campaign was effective in changing farmer behaviors

The MAAIF's FAW control campaign offered farmers a package of control options that included non-chemical IPM practices, chemical pesticides, and other GAPs to control FAW. Maize losses in Uganda were high in the first year of the FAW outbreak, but farmers responded swiftly to the FAW control campaign by adopting a good number of the practices promoted. From this package, 70% of farmers used various non-chemical IPM methods and engaged in GAPs, but probably the most striking results was that more than 70% of farmers adopted pesticides to control FAW. The ability to identify Fall Armyworm (as opposed the existing African Armyworm) was also quickly learned, as was the ability to monitor the larvae infestation across the fields. CABI found similar adoption rates in their earlier study, confirming the data (Tambo, et al. 2019). That is a notable change in behavior for resource poor farmers, given that FAW only arrived three years ago and suggests the effectiveness of the Ministry's information campaign in changing behaviors of many farmers.

Despite its success, there remains room for improvement. The campaign may not have put enough emphasis on some of the other cultural and mechanical control methods. Most farmers applied GAPs, but some practices such as crop rotations were not widely adopted. The reasons for less uptake of these method was not fully clear, but farmers may not have fully understood the direct connection to FAW control, did not find them useful, or were unable to take action in their farming system. Further analysis is required around whether the current package of options is sufficient for reaching farmers across income levels and cultural contexts.

Additional guidance is needed on chemical pesticide use

While the rapid adoption of chemical control by farmers was a major success and showed that the information campaign was effective, additional guidance is needed to ensure pesticides are used safely and effectively. Farmers consistently followed spraying schedules, but some struggled to follow the application instructions carefully, especially the dosage rates and numbers of sprays. In total, only 28% of farmers followed all of these recommendations. Wealthier farmers followed the recommendations more strictly than poorer farmers, probably because of better access to information and capacity to pay for multiple sprays in a season. One of the more worrying problems the survey surfaced was high levels of under-dosing amongst poor farmers compared with wealthier farmers. Under-dosing could lead to resistance to the chemical agents and this may not be a widely understood concept. There were also challenges with increasing dose levels as larvae matured, potentially exceeding safe levels of the chemicals. These details indicated that, for the campaign to be more successful in the future, messaging will need to shift from the basic idea of using chemical controls to providing greater detail on how farmers should use chemicals safely and correctly.

Farmers are actively experimenting

Experimentation with different chemical pesticide mixtures and homemade solutions was common among respondents. Farmers experimented with different types of pesticides, including Striker and Roket, used different dosage rates, varied numbers of applications, and tried various spraying schedules. Farmers who could not afford chemical control measures, or sought alternative and complementary control methods, also tested a range of homemade control products. These locally made products could be particularly beneficial to poorer farmers who cannot afford chemicals, although the efficacy of homemade pesticides remains uncertain.

Maize yields were improved due to the FAW campaign

Overall, maize yields were lower at the time of the survey compared with pre-FAW levels. However, results from the survey indicated that maize yield losses were likely reduced to a degree once FAW control measures were disseminated and adopted by farmers, although other factors such as increased rainfall or decreased pest incidence may have contributed as well.

Yield differences were found between different economic segments and genders. This may be partly explained by farmers not fully adopting all the FAW control measures such as time of planting, use of hybrid seed, fertilizer, correct use of chemical, spacing, rotation, etc. More farmers will need to adopt the full package of control measures to return maize yields back to pre-FAW levels.

The data indicated that wealthier farmers who implemented most of the FAW controls achieved higher yields in 2019 than poorer farmers who adopted fewer control methods. Women, who were the poorest farmers, also used fewer control methods than men and had the lowest yields. Clearly there was an equity issue at play which was partly explained by financial status, but there were several other factors, such as land and information access, education, and time availability that also contributed to lower yields. Large farms achieved yields of 2,965 kg/ha with an emphasis on chemical control, but even they were unable to achieve past yields of 4,448 kg/ha. They may have done better if they had implemented the full package.

Despite the initial yield loss, many farmers were confident after the campaign and the subsequent reduction in yield loss that FAW could be controlled. The wealthier segments were more confident about the future than poorer farmers. This confidence led almost all farmers to describe plans to increase or maintain their maize production, and the wealthier farmers had already planned to set aside money to pay for future use of pesticides. These trends suggest farmers expect to see yields recover further and that not only had farmers adopted the new control methods, they were able to see value in future investments. The question then, however, is whether the costs of an IPM strategy including non-chemical methods, chemical pesticides, and GAPs approach can provide enough revenue to cover their costs and provide an attractive profit.

Costs for different FAW control approaches are problematic for some farmers

Issues of financial capacity were clear throughout the data. Farmers with lower wealth levels faced consistent challenges in adopting recommended FAW control measures, and this resulted in lower yields.

With the arrival of FAW, farmers now need to scout fields more frequently, buy chemical controls, and invest in additional management practices. The recommended IPM and GAP methods include a fairly long list of activities and as each of these comes with a cost, especially in labor. Not all farmers had the time or could afford to put all these methods into practice, even when that may have resulted in some yield loss.

Chemical spraying introduced additional costs that were shown to be difficult for poorer farmers to afford. The cost of chemical control was approximately USh 50,000 for three sprays, equivalent to $21.64.[15] However, the percent of additional cost was highly dependent

[15] Exchange rate is approximately US$ 1 = 3700 Uganda shillings

on the farming system. For example, if a farmer used locally available Longe OPV seeds, no fertilizer, and weeded by hand, then the percent cost of additional insecticide to the systems was approximately 31% of overall production costs. However, for farmers who used more intensive production systems, including hybrid seed, fertilized, and weeded several times, the additional percentage cost of insecticide was less than 14%. The following price information provides an approximate breakdown of costs. While the costs for FAW insecticides were the same, if farmers sprayed three times at the recommended dosage, the percent investment of costs were almost double for the poorer farmers.

Table 9. Relative cost structure of maize production for low and high input systems

Costs (USD/acre)	Low input system (OPV seed)	High input system (Hybrid seed)
Tillage	25	25
Planting	Family labor	6
Seed	16	32
Fertilizer		60
Weeding	8	16
Pesticide	21.64	21.64
Totals	70.64	160.64
% pesticide	*30.63*	*13.47*
Production (kg)	500	1200
Revenue (USD/acre)	75	180
Gross margin (USD/acre)	4.36	19.36

Beyond pure costs, one of the major challenges that farmers face when having to buy inputs is access to cash. Most farmers do not have bank accounts, and most do not save money for specific products such as inputs needed for maize production. Most farmers will borrow from family or local traders for their inputs. In this case, the additional costs or credit required by farmers would be much higher for the poorer farmers who use fewer inputs than the farmers who use the full package.

Furthermore, guidance around economic costs, values, and thresholds of the various FAW control approaches was lacking, making farmers' decision-making even more challenging. The MAAIF recommendations did not provide any information on the costs of the control methods and did not advise farmers on the value of saving for this new cost. In future, it may be helpful for new FAW information to focus on helping farmers learn new skills, such as saving and cost benefit analysis, so that they can gain a better understanding of the merits of the different methods and their possible return on such investments. The farmers should also be informed about ideas such as economic thresholds, which help farmers to understand when it is economically effective to use sprays and when the cost is more than the benefit.

Learning and feedback mechanisms are weak

Data showed that farmers are utilizing feedback mechanisms to various degrees. More than 70% of farmers reported sharing their experience controlling FAW and 50% reported that they also requested additional information on FAW control. Almost all this feedback and information request was done in-person with group members, neighbors and friends, and extension agents. Approximately 15% of farmers communicated on radio but these were mainly the wealthier farmers. Very little information sharing occurred through social media, and the few farmers who used social media generally had more education or even advanced degrees.

Providing perspectives and asking questions is only to first piece to an effective feedback loop. Ideally, farmer innovation and learning are also being reported up to levels where it can be used to influence programming and policy, thereby better meeting farmers' needs and promoting a demand-driven agricultural information system. The components are in place for this to happen. Farmers are experimenting and innovating regularly. The data also showed that groups are providing a platform for innovation and peer-to-peer learning that is not equaled by other information sharing modality. Through groups, members can share experiences and feedback with other members in an environment conducive to learning.

However, the data suggests that the full potential of farmer feedback mechanisms is not being realized. Although feedback was given by farmers, it was not clear how much of the information volunteered by farmers was used by extension and research teams. Efforts to make the research-extension-farmer system more dynamic and more demand-driven are needed, so that new findings from the farming community can be incorporated into research and future extension services.

Summary

In the process of providing answers to the four research questions, the following constraints related to controlling FAW emerged:

1. **Farmer groups**: Most farmers relied on traditional informal methods for the exchange of information such as local social networks including family, friends, and farmer groups, but not all farmers are in registered groups and many groups are not well linked to extension services.

2. **Preferred information channels**: Most farmers preferred to access their FAW control information from extension agents, farmer groups, and friends and neighbors. However, a surprisingly low number of farmers used social media as a source of information. While this finding confirms the traditional channels of information flow, it highlights the problems that farmers have in using technologies or accessing more modern digital media information channels. The lack of uptake from social media networks either means the MAAIF's use of these technologies was not particularly effective or that these are not reliable ways of getting information to farmers, especially the majority of poor farmers.

3. **Farmer segments**: When comparing farmers' response to FAW control across economic quartiles, the poorest farmers had fewer sources of information, less financial capacity to follow recommendations, and used fewer of the FAW control methods. More attention needs to be taken to ensure that the information that reaches the majority of poor farmers is appropriate to their financial situation.

4. **Gender**: Women were the poorest farmers across all segments and generally had lower levels of access to information, fewer sources of information, and used fewer FAW control methods. Their yields were considerably lower compared with the wealthier farmers. In some cases, production by women farmers was less than half of the larger farmers.

5. **Adherence to chemical regimes**: Although uptake of chemical control was generally high across survey respondents, poorer farmers sprayed less times and used a lower dosage rate compared with more affluent farmers. Lack of adherence to the recommended spraying regime is a cause for concern and in some cases, low dose rates may be accelerating insect resistance to the chemicals which would lead to increased future costs. People who under or over sprayed may need more detailed information on how to use chemicals more effectively.

6. **Homemade solutions**: Almost 20% of farmers opted to use non-commercial control products, such as homemade sprays and ash inputs to control FAW. Extension agents did not promote these options, nor did they test their efficacy which is a missed opportunity as many poorer farmers were particularly interested in local control options that they can make themselves.

7. **Economics of control**: Many farmers failed to implement the full package of FAW control measures, and it was not clear if this was because some methods did not work, that some were not economically effective, or that farmers did not get sufficient information to put them into practice. Costs of different management approaches also appear to be a barrier to adoption.

8. **Farmer feedback**: The lessons learned by farmers through their experimentation of both homemade control methods and innovation in spraying protocols and mixtures was not verified by extension or research, and it appears that these lessons were not captured and used in the broader national strategy.

Recommendations

The following section provides options to consider and how new ways of addressing these issues can enable Ugandan farmers to control FAW more effectively.

Promote farmer groups and Farmer Learning Centers

The results show that groups were farmers' preferred channel for accessing information and enabling feedback because of both perceived convenience and trustworthiness. That said, farmer groups are not new, many farmers are not in groups, many farmer groups are dysfunctional, and there are not enough extension agents to reach all farmers in groups.

Nevertheless, if most farmers indicated that they prefer groups to learn, then a new approach to farmer groups is required. For farmer groups to work for FAW management, they need to not only be an entry point for management information but also a forum for collaboration, peer-to-peer learning, and innovation. In countries like Malawi, there has been a shift away from the traditional type of farmer group or Farmer Field School towards Farmer Learning Centers (FLCs). These FLCs provide an opportunity for a combination of Lead Farmers, extension agents, private sector actors, and farmers to set clear learning agendas based on local needs, organize demonstrations, and test new solutions both at a centralized farm and also on members' farms. The idea is to avoid the top down process found in traditional extension approaches, but rather to create an opportunity for farmers to learn about new technologies, test them with colleagues, and put them into practice.

Functional groups and Farmer Learning Centers can also be venues for other agricultural programming. These groups can explore other issues related to finances, gender equity, and how to reach more poor farmers with innovation and technology adoption. They can also foster Public Private Partnerships (PPPs) and address other key issues related to the needs of farmers at a specific location. These more modern groups are gaining interest with farmers as they are a more self-reliant approach to learning, and these types of options can be used by Ministries of Agriculture to share information, learn from farmers, and accelerate basic innovation.

Whatever the approach, extension campaigns need to ensure that the benefits of groups are equitable. This requires that groups take steps to be inclusive of poorer farmers, youth, and women farmers who are all critical to the agricultural sector, but also that extension focuses greater efforts on enabling more poorer farmers to join organized groups so they can more readily access information.

Use ICTs and social media more effectively

Despite the potential role of ICTs in sharing FAW control information, the mass communication platforms used by the message campaign had very little impact. Lack of equipment such as phones and radios, education levels, and language barriers were some contributing factors to the low adoption rates. Further assessing the reasons for this shortcoming is needed. The social media strategy also needs to be examined to determine whether poor implementation rather than the approach itself led to this outcome. Regardless, it is necessary to identify solutions to overcome both the supply and demand constraints before social media can be used as a powerful platform in contexts like Uganda.

Some of these issues could be overcome if farmer groups or FLCs take advantage of members with greater access to and capacity with technologies. For example, wealthier, more educated, and better equipped farmers can serve as a link or portal to receive this type of information and then set up mechanisms to share with others group members. Younger farmers who have better digital skills could also facilitate access to information from social media platforms. This in turn would support the national campaign's agenda on the use of more efficient mass communication platforms in disseminating and sharing information.

Support diverse farmer segments

General advice is essential to get basic ideas to the farming community. However, as farmers learn new approaches and methods, there will be different levels of adoption and adaptation. Much of this diversity in uptake and response is based around local contexts and the options, skills, and financial levels of farmers. Costs associated with different management recommendations were especially clear determinants in how farmers acted, regardless of whether they had received the FAW guidance or not.

To help more farmers, and especially poorer farmers, future advice could make more effort to package information towards the different farmer segments. For example, if farmers cannot afford the entire package, guidance could highlight the most essential elements of the FAW control approach that everyone should strive to achieve. Also, it may be helpful to explain why for example, three sprays are economically better than one spray, or why under-dosing is less effective in controlling the FAW and is financially inefficient. Farmers should also be advised about costs and how they can learn how to manage their finances to pay for next year's spraying regime. If farmers only want to use locally made control methods, recommendations should cover which ones show the most promise.

Improve options for women

The survey revealed that women farmers were generally poorer than their male counterparts and were less able to access information, all of which contributed to using less FAW control approaches and achieving lower yields. The results also suggested that if more women farmers were in groups, and especially if they were to join options such as a Savings groups, they may have more opportunities to save, to access credit, and through more regular group meetings to obtain the right information. This could possibility elevate their yields to similar levels as men and help close the gender gap. However, this survey did not explicitly explore many of these themes, and additional research is needed to uncover the nuance related to women farmers' differential access to information, use of pesticides and concomitant lower yields.

Facilitate better adherence to chemical regimes

Farmers responded in large numbers to the MAAIF guidance to use pesticides if pest levels exceeded 20%. Evidence also showed that much of the pesticide guidance was followed closely. However, the guidance also contained gaps that caused some farmers to deviate from recommended application approaches. To help farmers use the chemicals more efficiently or effectively, it would be useful for the next round of FAW guidance to add additional details on:

1. Why spraying three times is recommended.
2. The different dosage rates during the season based on pest development stage, and why that is important for effectiveness.
3. The economic thresholds for spraying and how to do additional economic analysis of the value of purchasing and applying chemical pesticides.
4. The cut-off dates, so that farmers do not spray when the larvae can no longer likely to controlled by the pesticide.

5. Which types of sprays farmers are most commonly using and which provide best value.
6. How farmers should rotate types of chemical sprays to avoid resistance.

Assess farmer innovation and homemade solutions

The survey indicated that farmers were both (1) experimenting with a diverse range of pesticides, applying various doses, and mixing chemicals; and (2) testing homemade products and control methods. In fact, nearly 20% were testing some form of homemade product. Some of these experiments may yield valuable information on more effective strategies that other farmers could use and may be of particular value as low-cost alternatives to chemical pesticides that are difficult for some farmers to afford.

Farmer experimentation is a rich learning resource. It was observed in some interviews that research staff recognized that farmers were using ash and pepper sprays. However, there was little evidence that extension or research valued or captured these local experiments within the existing learning system, even as NARO cited its own research on biological controls.

In contrast, the Department of Agricultural Research Services (DARS) in Malawi partnered with farmers to test their homemade control approaches, such as neem and tobacco. DARS conducted formal scientific trials to assess the efficacies of this and other homemade products. While the specific homemade products from Malawi may not apply in the Ugandan context, the key point is that not only did the research team listen to farmers but also partnered with farmers to test farmer-developed approaches on co-managed plots. Their experimental findings were then incorporated into the national research agenda around FAW and could potentially become formal recommendations for FAW control (Kachingamba, et al. 2019). This type of farmer-based research approach could be adopted in Uganda to test the validity of the locally used control methods. Results would be especially important for poorer farmers, who have smaller plots and often do not have the resources to buy the full FAW package.

Help farmers better understand and manage the economics of FAW control

As more new technologies are introduced into the smallholder farming sector, greater attention needs to be given to helping farmers understand the costs and benefits of adopting technologies and finding ways to link to markets. In the case of the overall IPM approach for FAW control which includes chemical and non-chemical control methods as well as general GAPs, farmers should be provided with more information on the expected costs and returns of different approaches.

This may require providing farmers additional ways to pay for FAW control measures. Many NGOs have found that helping farmers to learn financial and management skills through savings and credit groups is an effective way of enabling farmers to gain skills in financial literacy and apply this to their farming operations. The Private Service Provider (PSP) model is one means of building financial literacy skills and strengthening groups (bavois 2013). Professional PSPs are paid by group members to support group needs and they in turn need to demonstrate that they provide benefits to farmer group members. In addition to learning and managing their savings, under the Savings group and PSP model farmers can access credit from the group and work on business plans for their annual crops. The PSP can also prepare and facilitate the farmers to access credit from formal financial institutions by leveraging the group as collateral, and link farmers with agro-input suppliers, transporters, and eventually buyers. All of which helps farmers to become more commercially minded and be in a better position to invest in the full set of FAW control methods and productivity options.

Strengthen farmer feedback mechanisms

The survey showed that farmers were innovating, experimenting, and sharing feedback with peers, within groups, and to extension agents. However, this feedback was not seen to influence programming or policy. More could be done by extension agents and researchers to gather data from farmers and incorporate this information into the larger agricultural information system for FAW control. Efforts to strengthen farmer feedback can therefore lead to a more demand-driven extension system that better meets farmers' FAW management needs.

Refine the FAW control information campaign

The FAW package in Uganda is already providing farmers with important options to help reduce crop losses. Results show that farmers' behaviors are changing, and yields are rebounding from year to year. Yet more can be done to improve the technical guidance provided to farmers. MAAIF should continue to explore other and new options to improve both FAW control and improve maize productivity through collaboration with the international research community, private sector, and specialized groups such as Feed the Future Innovation Labs.

Incorporating guidance on natural enemies to the FAW may be one option for strengthening the information campaign. Research by the Feed the Future Innovation Lab for Collaborative Research on Sorghum and Millet in Central and South America identified two effective natural enemies which control FAW and which have mass-production potential in Africa (IPM Innovation Lab 2020). Uganda is the process of its own testing and can benefit from learning more about mass production of these natural enemies against FAW.

Similarly, there are improved maize varieties in existence that could be used to provide farmers with a fairly long-term method to control FAW, which if used in combination with other aspects of an IPM approach would further reduce reliance on synthetic pesticides. Although GMO maize varieties are not yet legally approved in Uganda, there is increasing interest in Africa for using this type of technology, which could provide a proven means of not only returning production levels to pre-FAW yields but going beyond them.

Develop and/or strengthen information and learning centers for FAW

Finally, there is also merit in developing and building on existing clearinghouses for FAW and other invasive species control, such as those created by CABI, USAID (Agrilinks) and the FAO, where scientists and field practitioners could conveniently access information, learn from a broader set of actors, and avoid duplicating efforts. A geographic focus on Africa would be doubly valuable. This center could assist with updating all the communication materials and supporting the recommendations based on new evidence. These options could assist research and extension teams in Uganda and elsewhere to gather information and use this as the basis for future information sharing and feedback.

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