Food and Agriculture Organization of the United Nations

Fall Armyworm Expert Meeting

Accra, Ghana 18-20 July 2017

Synthesis

25 September 2017

Fall Armyworm (*Spodoptera frugiperda*)

Fall Armyworm (FAW) is an invasive insect pest native to the tropical and subtropical regions of the Americas that recently arrived in Africa. It was officially reported for the first time in Nigeria in January 2016, although it has been reported from Cameroun in December 2015. It has quickly spread across much of Sub-Saharan Africa and its presence has been detected by 31 African countries as of August 2017. FAW is a polyphagous pest of many important crops (including maize, sorghum, millet, rice, wheat, vegetables and cotton), but prefers maize and other plants of the grass family. FAW probably arrived in Africa without its complete cohort of natural enemies (predators, parasitoids and pathogens) that can provide a high level of natural control in their native Americas. As a new pest, farmers and extension agents are still learning how to identify FAW, understand its biology and ecology, and how to manage it. Both maize and FAW are native to the Americas, where farmers have been managing it and researchers studying it for many years. Much can be learned from this experience and knowledge that will be useful in Africa.

To share the knowledge and experiences with colleagues in Africa, FAO organized an Expert Meeting in Accra, Ghana from 18-20 July 2017. Over forty colleagues from the Americas, Europe, and Africa participated in the meeting.

African Context

Although FAW has found fertile territory in much of Sub-Saharan Africa, the ecology and socio-economic context of the farmers is often dramatically different from that in the Americas. Thus management and policy recommendations for FAW in Africa must carefully take into account the resources and incentives surrounding the farmers who are and will be affected by FAW. Much of the maize produced in the Americas is produced on commercial farms, by farmers who have access to credit, insurance, up-to-date access to inputs and information and relatively stable or predictable markets for their production. These farmers typically plant large areas of monocultures, intensively using inputs to produce high productivity and production. Although these production systems are present in some of areas of Sub-Saharan Africa, especially southern and eastern Africa, the most common cropping system and farmer in Sub-Saharan Africa is quite different. In Sub-Saharan Africa over 95% of the maize farmers are smallholder family farmers, often growing a diversity of crops in small plots of often

degraded soil, have limited access to inputs and services, and often have little access to adequate storage facilities and receive low prices for the maize they sell to markets. It is for this context that management and policy recommendations must be made to help smallholder family farmers manage FAW in Sub-Saharan Africa.

A. Farmer sustainable management of FAW

The ultimate goal of FAO's and partners' response to the rapid spread of FAW across much of Africa is to enable African farmers sustainably manage the insect in their fields, with the help of local, national, regional and international research, educational, extension and policy organizations. Farmers need access to information, recommendations and resources to help them manage the pest sustainably.

The foundation for FAW pest management in African small holder family farmer agricultural production systems should be on sustainable integrated pest management, maximizing prevention of the problem through agroecological management. The sustainable manipulation and utilization of plant host resistance, plant diversity, adequate soil health leading to crop health, and the conservation and maximization of natural control are key components of a sustainable management system. There will be no "silver bullet" to manage FAW. Only when farmers and extension agents have sufficient knowledge of the biology and ecology of the insect and their agroecosystem will they be able to successfully integrate the tools at hand of agroecological management, biological control, cultural tools, along with plant host resistance and the use of biological and synthetic chemical insecticides.

A first step to understanding the ecology of FAW in Sub-Saharan Africa will be to map the cropping patterns of the different host crops of FAW in sub-regions. Simple crop calendars will help determine the potential of FAW population increases and local movement among crops. This understanding of landscape ecology proved very important in Brazil, where continuous production of host plants provided food sources to maintain high FAW populations.

A second key yet-unknown factor regarding FAW in Africa is whether it will develop significant population movement patterns that will provide important information to determine the potential for movement-based early warning systems. A system of pheromone traps using standardized lures, traps and reporting systems can help answer this question.

Immediate management recommendations for farmers

Although there is still much to be tested and adapted to the conditions in Africa, some immediate recommendations for farmers can be made, drawing on experience from the Americas:

- To reduce FAW oviposition on maize, try increasing diversity of plants. Intercropping with cassava (not a FAW host plant) may reduce oviposition on maize. Some plants "repel" adult FAW and could be planted in rows. Plant diversity can also increase natural enemy populations.
- Visit your field regularly (at least once a week, more often when high FAW populations) to inspect health of crop, FAW and natural enemy presence.
- FAW female adults lay their egg masses directly on maize leaves. They are easily observed and can be quickly hand-crushed, eliminating about 100 eggs very effectively.

- Maize plants have the capacity to withstand defoliation without suffering yield loss. Not all leaf damage causes significant yield loss. Yield response to defoliation is dependent on growth stage of the maize: some stages are more susceptible to defoliation damage than others. It is important not to panic at the sight of FAW infestation.
- FAW has many natural enemies. In the Americas upwards of 50% of FAW eggs and larvae are killed by naturally occurring parasitoids, predators and pathogens. The populations of natural enemies can be nurtured or severely damaged. Plant diversity encourages natural enemy populations. Many types of chemical pesticides are known to kill natural enemies.
- Most maize farmers in Africa do not apply insecticides to their maize. The costs of production and the prices received by most smallholder maize farmers makes the use of insecticides economically unstustainable. .
- Even when economically justified, the use of insecticides in smallholder maize is often ineffective (poor application, timing, or pesticides not effective), kills natural enemies, and presents human health and environmental risks.
- Botanical insecticides (e.g. neem) and pathogens (virus, bacteria and fungi) can be effective against FAW. They can be produced locally. There are many such products registered in the Americas. Their use should be encouraged and promoted across Africa. Some of the pesticides being used and given out for FAW are highly hazardous pesticides (e.g. carbosulfan, endosulfan, methyl parathion).
- Some smallholder maize producers in the Americas apply ash, sand or soil directly to the whorl of infested plants. Ash and sand may desiccate young larvae. Dirt may contain entomopathogenic nematodes or Nuclear Polyhedrosis Virus (NPV) that can kill FAW larvae.

Areas for short-term research

In addition to immediate recommendations, a number of areas should be short-term research priorities:

- Inventory of natural enemies (predators, parasitoids, pathogens) of FAW in its new range in Africa. Quantification of their importance in FAW population dynamics. Identification of gaps and candidates for classical biological control programmes with introductions from the Americas following careful pre-release studies.
- Assessment of yield loss from FAW under different growing conditions representative for Sub-Saharan Africa (soil types and soil health, nutritive status of crops, moisture availability, crop associations, soil management, variety, stage of infestation, etc.) under different pest pressures. Based on these studies and the costs and efficacy of control and the prices received by farmers for their harvest, action thresholds can be developed and recommended.
- Effectiveness, availability, costs and recommendations for the use of biological pesticides. Among the botanical pesticides, neem has been widely tried. Among the biological pesticides, virus (NPV), bacteria (*Bacillus thuringiensis*), and fungi (*Metarhizium* and *Beauveria* spp.) have all shown promise.
- Standardization of protocols for determining levels of infestation in fields, digital methods (application) for reporting, platform for receiving and analyzing information, and retuning advice and products to farmers for action.
- Determination of movement patterns and use of pheromone traps for local scouting and actionable information. Standardization of lures and traps.

- Review of cropping patterns and landscape information to determine area-wide management and recommendations based on FAW ecology. Effect of planting dates and staggered plantings on FAW infestation and damage.
- Studies of the influence of plant diversity (multi-cropping systems and the use of border plantings as repellents) to reduce FAW oviposition and increase populations of natural enemies.
- Trials of cultural practices (application of ash to whorls, use of soaps, sprays of sugar water to attract and feed natural enemies) to test their validity and effectiveness.

Areas for longer-term research

In the longer-term, research should continue to:

- Explore local production and application of biological control agents, especially the egg parasitoid *Trichogramma*, NPV virus and Bt bacterium.
- Test widely in Africa FAW-resistant maize inbred lines, e.g. from CIMMYT, for their responses to FAW, for developing and deploying Africa-adapted FAW-resistant elite maize hybrids/OPVs.
- Test FAW-resistant temperate maize inbred lines (e.g., from USDA-ARS), as sources of resistance, for use in maize breeding programs in Africa.
- If requests are received from countries, support biosafety reviews.
- Lessons learned about the use of transgenic maize in the Americas and South Africa should be reviewed. Concerns about the development of resistance to transgenic maize, the costs of such technology and accessibility by smallholder African farmers, and the implications for seed-saving on the sustainability of such options were raised.

Synthetic chemical pesticides

In order to use pesticides in a targeted and specific manner and to reduce the risks involved in applying them, the following aspects should be considered and further developed:

- Review pesticides' impact on natural enemies, human health and environment.
- Rotate mode of action to slow down resistance.
- Compile list of registered pesticides by country.
- Rank chemicals by risk level – including resistance history – experience.
- Work with regional and sub-regional pesticide registration bodies to prioritize registration of low-risk pesticides.

Most maize farmers in Sub-Saharan Africa do not apply insecticides to their maize. Current government responses of providing insecticides to farmers to spray against FAW and the recommendations and financing of some development partners risk getting smallholder family maize farmers on an unsustainable "pesticide treadmill" from which they may not easily escape. The current costs of production and prices received by many smallholder farmers for their maize make the increased use of insecticides economically unsustainable.

Bio-Pesticides (biological and botanical)

The use of bio-pesticides present viable options for effectively and sustainably managing FAW in Sub-Saharan Africa. Experiences from the Americas demonstrate that they can also be produced locally. The potential for local production and quality control of botanical and biologically-derived pesticides (from virus, bacteria and fungi) is great and should be explored. To this end, FAO will work with partners to develop quick access to bio-pesticides by African smallholders. The following steps will be taken:

- Promote the fast-track registration of bio-pesticides (including Bt, NPV, neem and other botanicals) against FAW in all African countries.
- Determine and promote the availability of these bio-pesticides in Africa.
- Promote the local production of the bio-pesticides.
- Explore the possibility of botanical pesticides from African plants & local preparation.
- Promote the quality control of the products.
- Promote the purchase and use of the products.
- Advantage & Information provided about action of bio pesticides

Biological/Natural Control

It is important to enhance indigenous natural enemy populations and to minimize pesticide use. Examples from Brazil and the United States show that FAW has a high level of natural control that should be protected and promoted.

Surveys for presence of indigenous natural enemies of FAW in Africa should be conducted to determine to what extent existing predators, parasitoids and pathogens of FAW are effective and how their action on FAW may be enhanced. The gaps should be identified to determine promising candidates in the area of origin of FAW for a classical biological control programme (see also 'Areas for short-term research').

The impact of agricultural practices (plant diversity, elimination of certain pesticides, planting dates, etc.) on natural enemies' populations and effectiveness of FAW management should be further studied and technical and policy recommendations developed to support their implementation (improving soil health, managing plant diversity).

Surveillance and Early Warning

The monitoring component of the system should be established within the context of existing community Integrated Pest Management (IPM) programmes such as Farmer Field Schools (FFS) and community-based systems.

The system should consist of field data collected at the farm level that is centrally collated so that it can be shared and analysed at different levels in order to produce useful information in the form of relevant advice and early warning for all stakeholders. The collection and transmission of field data is the foundation of the system and the basis for early warning. The usefulness and accuracy of the early warning system is a direct function of the quality and timeliness of the monitoring component. It will be critical to involve stakeholders from the various levels at the beginning to identify what information, advice and early warning products should be

derived from the field as well as any other data they may need to order to meet their individual or specific requirements and needs. These outputs should be clear and delivered on time. The system should include incentives and a feedback mechanism that encourage and promote regular and timely provision of high-quality field data to ensure a constant flow of data for early warning purposes. Stakeholders at each level should receive basic, refresher and updated training in all aspects of this system.

The system will allow action to be taken at different levels:

- Farmers: understanding of their ecosystems, FAW and necessary actions
- District: threat potential, alerts
- National: planning, food security, task force
- Sub regional: food security, planning, response
- Regional: food security, planning, response

Given its demonstrated expertise and experience in continental-wide and global early warning systems for agricultural transboundary pests, FAO should take the lead in the development and establishment of the FAW monitoring and early warning system, and utilize the specific expertise of other institutes. Prior to full implementation and operationality, various elements of the system will need to be tested in two pilot countries per region (West, Central, Eastern and Southern Africa). Additional research will be required to further strengthen some aspects of the system. For instance, there may be scope to eventually expand the system to include other important transboundary plant pests and diseases.

The surveillance component involves the collection, recording and transmission of field data primarily by farmers either as individuals or organized as communities such as FFS and other community-based programmes. This may include other relevant stakeholders such as extension agents, CABI plant-wise health clinic personnel, NGOs, and CBOs. National and district officials should encourage large-scale public and private sector farms to participate in national surveillance systems.

Field data can be collected in order to (a) determine FAW presence at the local, district, national and regional levels, (b) take immediate action, (c) monitor FAW movements and spread, (d) identify gaps in monitoring, (e) identify potentially threatened areas or areas at risk, and (f) provide forecasts and early warning.

There is a need to standardize the data that is collected in the field for FAW monitoring and early warning. This is critical in order to allow comparative data analysis across countries and regions for situation assessments and early warning at the district, national and regional levels. Standardization also facilitates the sharing and exchange of data.

The amount of data to be collected should not be too large because this will affect the ability to easily record and transmit the data. Therefore, only the basic and most important data relevant to FAW should be collected; in other words, the data required to assess the situation and provide early warning. This is referred to as a core data set and it should be standardized for all countries and users. Additional data is likely to be required for research and other purposes that may only be collected on an ad-hoc basis. This is referred to as an extended data set, which may vary depending on the purpose.

There are two primary sources of field data: field surveillance and pheromone traps.

Field surveillance consists of inspecting fields by farmers, community focal points, agricultural extension agents and others and recording of relevant data. This should be undertaken at the appropriate time and frequency. By

training and authorizing users in the system, data can be "crowd-sourced" – inputting of data from far more users than possible under the classical extensionist-technician model, which limited inputting of data from far fewer "official" sources. In order to compare the results of field scouting, a standard protocol is required on how to scout fields and what information to collect. Tools will need to be developed to allow the recording and transmission of data collected during field scouting. These issues are discussed further in the relevant sections below.

Pheromone traps: Data from pheromone traps can complement but not substitute field scouting. Trap data can be used to relate adult catches to the potential scale of breeding and for monitoring the spread of FAW. Pheromone traps should be used judiciously and on a limited scale in those areas in which their impact can be of the most benefit. This will involve the initial testing of trap design and pheromone lures to determine the most effective combination. Ideally a single standardized trap and lure should be utilized. Further testing will be required for the proper placement and distribution of traps in the field as well as protocols to be established for data collection, recording and transmission. This should be followed by procurement of the traps and pheromone, delivery and assembly, proper placement in the field, and training in the use and maintenance of the traps, initially in several pilot countries, with further upscaling later. In addition, pheromone traps can be used for monitoring for potential mass movement patterns, such as occurs with fall armyworm in North America.

It is critical that data collected in the field – both from scouting and traps – are recorded and transmitted in a timely manner. Without transmission to a centralized database, it will not be possible to use the data to assess the current situation and provide early warning and advice to stakeholders.

A standardized methodology should be used for data collected by field scouting and pheromone traps. Existing protocols for FAW should be reviewed and adapted for use in Africa. Standardization will help to ensure the maintenance of high quality data and facilitate comparative data analysis.

There is a need to develop a robust tool to allow the collection, recording and transmission of field data. This tool must be simple, straightforward and intuitive to use as well as easy to maintain and update. Given that nearly all farmers or communities have a mobile phone and the potentially large number of users involved in FAW monitoring, it is preferred to take advantage of what already exists rather than procuring new devices that are difficult and expensive to distribute, manage and repair. Using existing mobile phones avoids any personal or institutional ownership issues of devices. Another advantage is the geographic positioning system (GPS) function integrated into most phones that can be used for automatic geo-referencing of field data. Therefore, an app should be developed for Internet-enabled ("smart") mobile phones as well as for non-Internet-enabled ("dumb") phones that rely on SMS.

While smart mobile phones are the ideal platform for data collection, recording and transmission because of their Internet connectivity and extended capacity and functionality, it cannot be assumed that all farmers or community focal points will have a smart mobile phone. For example, three out of four people have mobile phones in Kenya but only a third of Kenyans had access to the Internet in 2013. Although Internet access is expected to increase as the technology becomes more available and prices come down, there is still a requirement to develop an app for non-Internet-enabled mobile phones that rely on SMS for data transmission. The app would be used by individual farmers who own a mobile phone. If farmers do not own mobile phones, then a community focal point with a phone could collect the standard data from the farmers, record and transmit it from his/her mobile phone.

Weather information can be used to in conjunction with FAW monitoring data and cropping patterns to model movement patterns and population changes over time. These modelling exercises should result in useful products for early warning of FAW arrivals and population levels.

B. Baseline and Impact Assessment

The introduction of FAW into Africa has the potential for impacts on maize (& other crops) yield, household incomes, food and nutrition security, costs of production, environmental contamination and human health effects from pesticides use, and impacts on trade.

It will be important to establish an inter-disciplinary team to determine objectives and methods of collecting both baseline data and measuring change over time to be able to evaluate the impact. The team should design and train in implementation of instruments to collect data using standardized protocols. These methods and assessments should build on existing tools and methodologies (e.g. vulnerability assessments).

C. Communications, Training, and Awareness

Key to affecting positive implementation by farmers and decision makers will be raising awareness about the issues, developing clear and consistent communications and training and educating farmers about FAW in the context of their systems. Harmonized and consistent messages and materials need to be developed.

Awareness raising is key, especially in the early stages of the new invasion. Farmers and decision-makers need to understand and fully appreciate the potential impacts so as to take appropriate action. Care must be given to create awareness without inciting panic.

Clear, consistent, coherent messages must be sent out via multiple channels to diverse audiences. It is important to take advantage of traditional existing channels: radio, community meetings, pamphlets & brochures, technical guidelines, policy briefs, presentations, events, but also vitally important to utilize modern communication channels, such as SMS messages, videos, FaceBook, WhatsApp groups, Instagram and diverse internet portals, including FAO and partners (Lancaster University, CABI, IITA, etc.). Simple, clear practical advice for farmers and farmers' organizations is essential. This material must be made available in local languages. For all communications, it is important to partner and train journalists & students.

The linchpin activity will be working directly with farmers and their organizations. Only farmers in their fields can successfully sustainably manage FAW. Many countries have dedicated extension agents, employed by their governments, NGOs, farmers' organizations and private consultants. FAO has led the formation of Farmers' Field Schools across Sub-Saharan Africa for over twenty years. Thousands of field schools have successfully worked with hundreds of thousands of smallholder family farmers to help experiment, learn, share and implement sustainable management of their production systems, based on an agroecological understanding and appreciation of their systems.

FAO will build on this firm footing to bring FAW management to the existing thousands of field schools, and expand dramatically into the most effected FAW areas, based on a unified curriculum and linked to monitoring and continuous feedback and improvement. Master Trainers will be trained in six-day courses about FAW biology and ecology, including agroecological analysis and special topics of discovery regarding FAW

management. As Master Trainers are trained, they will work with other trainers of other Field Schools across their regions.

D. Coordination

Good coordination is essential given the scale and complexity of the endeavor. Locally it is essential to coordinate well with local community and farmer leaders, who will champion the work at a local level. They should have the support of local and traditional leaders. Farmers and their organizations should be empowered to lead initiatives. Building on local coordination, multi-stakeholder task-forces should be organized at the national level. The national task-forces should incorporate coherent policy and technical support. There should be good commitment and buy-in from all partners.

At sub-regional and regional levels, phytosanitary, economic and political support should be sought. These include the economic commissions, the Inter-African Phytosanitary Council and the African Union.

FAO should play a coordinating role with development partners to ensure coherent work, avoiding duplications and work on generally-accepted priority areas. FAO should actively play its role as honest broker using its convening power with both development and resource partners.

FAO can also play a key coordinating role with research and implementation partners internationally and regionally, including with the CGIAR system, national research and extension systems, NGOS, and projects.

Annexes

Annex I: Key FAW Messages

Annex II: List of Protocols to Standardize

Annex III: List of Participants

Food and Agriculture Organization of the United Nations

Fall Armyworm (FAW) in Africa: Key Messages
FAO

- FAW has arrived in Africa from the Americas and is here to stay. The pest will not be eradicated.

- FAW can feed on over 80 crop plants, but prefers maize.

- FAW has quickly spread across the continent and will likely soon be present in all of Africa and then possibly continue its spread.

- There are tens of millions of smallholder maize farmers across Africa who must learn to manage the pest, in the context of their cropping systems.

- Key to helping farmers manage FAW will be to help them and extension agents to learn key concepts of FAWs biology and ecology and best practices for its management. Massive roll-out of a learning, training, and communications programme will be necessary, principally through village meetings, Farmer Field Schools, Plant Health Clinics, national extension programmes and mass communication campaigns.

- Farmers and researchers have been managing and researching FAW in the Americas for many decades. Their experience is being harnessed to help develop sustainable management options for smallholder family farmers suitable to their cropping systems.

- In the Americas, FAW is attacked by a significant number and diversity of natural enemies. These naturally-occurring predators (ants, earwigs, wasps, etc.), parasitoids (small wasps), and pathogens (bacteria, virus & fungi) can cause up to 50% natural mortality of FAW in the field.

- Spraying insecticides early in the crop cycle will kill off the natural enemies and may not be economical.

- FAW mostly causes indirect damage – feeding on leaves. Occasionally it attacks the cobs or burrows into the stem. While very dramatic looking, leaf damage can be compensated for by a well-fed and watered maize plant. Leaf feeding by FAW can cause some yield reduction, but the damage may look far worse than the impact on yield. Even with high levels of FAW infestation at certain periods, maize plants are capable of compensating for the damage and not significantly reducing yield. Farmers should not panic at the sign of FAW in the field.

- Some pesticides don’t work against FAW, because the pest has developed resistance to the pesticides.

- Some pesticides being used against FAW are very toxic to humans and cause environmental contamination.

- Effectiveness of insecticides against FAW also greatly depends on the application technique, dose and formulation. Once the FAW is down in the whorl, the insecticides must reach them there.

- Spraying with backpack sprayers without delivering material directly into the whorl is often ineffective. In addition, farmers in Africa rarely use personal protective equipment due to their cost and lack of adaptation to local conditions, and have little information on the risks of different pesticides.

- The vast majority of maize smallholder farmers in Sub-Saharan Africa don't use pesticides in their maize. Farmers consume a part of the maize they produce, and those who sell maize to markets often receive a low price.

- Spraying insecticides several times can dramatically increase the costs of production, making the maize economically unviable.

- Some governments are giving away pesticides to maize farmers to combat FAW. Some of the insecticides are acutely toxic to humans, some have been banned in other countries for health concerns, some are ineffective, and most will destroy natural enemies which can provide natural pest control. This policy may be starting smallholder maize farmers on a pesticide treadmill that may well have negative impacts.

- Botanical insecticides (e.g. neem) and pathogens (virus, bacteria and fungi) can be effective against FAW.

- Some smallholder farmers in the Americas report sprinkling ash, sand or dirt into whorls. Ash and sand may desiccate young larvae. Dirt may contain entomopathogenic nematodes or Nuclear Polyhedrosis Virus (NPV) that can kill FAW larvae.

- Local, small-scale production of the *Trichogramma* egg parasitoid, FAW virus (NPV), and *Bacillus thuringiensis* bacteria (Bt) have shown to be effective in Brazil and Cuba. Cuba has developed local, small-scale production facilities of natural enemies and bio-pesticides.

- Farmers must enter their fields often, be able to identify FAW life stages and damage and natural enemies. Squashing egg masses and young larvae is a very effective tactic for smallholder maize farmers.

- Plant diversity (intercropping other crops with maize, use of varietal mixtures and use of certain species in border-rows) can help to: 1. Reduce oviposition by FAW on maize, and 2. Maintain populations of natural enemies.

- Longer-term solutions of resistant or tolerant maize varieties have potential, but are several years off.

- Unlike FAW in the Americas, or the African Armyworm, FAW in Sub-Saharan Africa may not develop a migratory pattern. Most likely the populations will be resident, surviving on weeds and other plants during periods without maize.

- The utility of pheromone lures and traps needs to be determined. They may be useful in detection of population movement patterns. They may be useful at a local level to alert community members and farmers about higher adult populations.

ANNEX II: List of Protocols to Standardize

1. FAW field sampling and data recording:
    a. Number of plants, pattern
    b. Observation
    c. Data collection (app)

2. Pheromone traps:
    a. Standardized lure & trap
    b. Design of area-wide grid
    c. Data collection (app)

3. Impact assessment:
    a. Determination of measurements and development of standardized protocols
    b. Standardized data collection

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