Indian Farming **69**(01): 51–54; January 2019

The emerging threat of Fall Armyworm in India

time for proactiveand collective action

A K Padhee[1] and B M Prasanna[2]

International Crops Research Institute for the Semi-Arid Tropic (ICRISAT), New Delhi 110 012

*The Fall Armyworm (*Spodoptera frugiperda*; commonly referred to as "FAW")is a crop pest native to the Americas. It was first formally reported in West Africa in January 2016 and has spread to several countries across Africa (except a few countries in North Africa). The pest has been reported for the first time in India in Karnataka in July 2018, and subsequently in a few other states, such as Andhra Pradesh, Telangana, Tamil Nadu, Maharashtra and Odisha. The Indian Council of Agricultural Research (ICAR) – National Bureau of Agricultural Insect Resources (NBAIR) issued a 'pest alert' on 30th July 2018 based on results of surveys conducted between 9-18 July 2018 that recorded more than 70% prevalence of the FAW in a maize field in Chikkaballapur, Karnataka. The pest later spread to eight to nine districts of Karnataka, such as Shivamogga, Bellary, Belgaum and Hassan. The FAW damage has been the highest in maize, while several other crops, such as sorghum, sugarcane, millets and vegetables are also vulnerable to the attack. The pest has caused significant concerns among the stakeholders and heightened the attention of the Government machinery.*

Key words: Fall Armyworm, Integrated pest management, Smallhoders

THE Fall Armywarm (FAW) is not new to the scientific community. This highly destructive and invasive insect-pest has been prevalent in the America more than a century.As per the assessment made by CGIAR Research Program on Maize (MAIZE)led by the International Maize and Wheat Improvement Center (CIMMYT), the FAW in the last two years caused damage to more than 1.5 million ha of maize crop in Africa alone affecting the food security and livelihoods of several million smallholder farmers. The Food and Agriculture or Organization (FAO) experts recently have warned that FAW is likely to spread from India to other parts of Asia, with south-east Asia and south China mostly at risk. The invasion by fall armyworms could potentially become global and the damage caused by the pest to maize crops could have far-reaching consequences, unless synergistic inter-institutional efforts are made by various institutions at different levels, including local, national, regional, and international.

Fig. 1. Leaf damage by FAW (*left*), FAW damaging maize crop (*right*)

Fall Armyworm biology and life cycle

The FAW moth populations are capable of migrating very fast (almost 100 km per night and nearly 500 km before laying eggs) and thus, can invade new areas quickly. The pest completes its life cycle in about 30-45 days (depending on weather conditions). In cooler temperatures, the life cycle may extend up to 60-90 days. The female moth lays on an average about 1500 eggs attaching them to the foliage; the egg stage lasts for only 2 to 3 days in warmer weather. The FAW, in general, has six larval instars (stages) before it goes for pupation. The entire larval stage lasts for 14 to 30 days depending on the weather conditions, especially temperature and humidity.

FAW is one of the most destructive crop pests, with a wide spectrum of host range including maize, rice, sorghum, sugarcane, millets, soybean, vegetables, cotton, etc. Yet, we must recognize the fact that FAW can be effectively managed by adopting appropriate integrated pest management (IPM) strategies suitable for diverse agro-ecologies and cropping system landscapes in India. It is in this context, the article intends to sensitize the stakeholders, including farmers, extension workers, scientists and policy makers in India on the approaches to sustainably manage the insect-pest before the pest can cause significant economic damage.

Destruction of leaves, stems or reproductive parts of the crop plants is done mostly by the last 3-4 instars of FAW; therefore, control is best achieved early in the life cycle of the pest, not at the later stages. The damage might result in extensive defoliation (Fig. 1). The insect normally pupates in the soil lasting for 8 to 9 days in summer, which may extend up to 20-30 days in cool weather. The nocturnal adults live for 10 days on an average and are most active during warm and humid evenings.

Effective monitoring and surveillance

Scientists of University of Agricultural Sciences, Bengaluru, and the University of Agricultural and Horticultural Sciences, Shivamogga, in Karnataka state have scientifically validated the incidence of FAW in the maize fields (Sharanabasappa, 2018; Shylesha et al., 2018). As reported in the literature, the FAW moth populations can travel several hundred kilometers during its life span, and the egg laying by the females is also profuse. Being polyphagous, the pest can damage to a number of crops. Therefore, it is of paramount importance on the part of the States of India (especially those where the pest has been already noticed) to nip the problem in the bud. A mass awareness campaign needs to be made to build necessary awareness (avoiding panic at the same time), amongst the farmers and extension workers as to how they can effectively diagnose/recognize various stages of the pest (eggs; moths; early stages/instars of the larvae) and manage/control the situation with right interventions, by following integrated pest management (IPM) practices. In no uncertain terms, we need to advise farmers or extension personnel (and even scientists) Not to panic or create panic when they notice FAW in any crop field. As the pest has appeared in specific areas of the country, creation of awareness through traditional means, such as pamphlets/posters showing characteristics of the insect pest, including pictures of egg mass and larvae (for hand collection and destruction by farmers themselves at the initial stages), radio/TV broadcasts, as well as through use of information and communication tools (SMS/social media) is important to rapidly spread the message. An open-access, science-based, animated video was developed and disseminated jointly by Michigan State University, CIMMYT, IITA and USAID to aid semi-literate, smallholder farmers for effectively identifying and scouting for FAW. This video, available in English and French, is being localized further into various languages across Africa and Asia.

FAW monitoring and surveillance systems: The monitoring and surveillance systems by public and private extension machineries through setting pheromone traps would be an effective mechanism to monitor the movement of the FAW populations within the targeted geographic locations. Trained technical personnels based on their knowledge of the pest and the concerned agro-ecosystem can also suggest to the affected farmers on specific interventions based on IPM. Rapid capacity building of such staff by scientific institutions (with required domain knowledge) is extremely important. The National Agriculture Research and Extension System (NARES), consisting of the vast network of Indian Council of Agricultural Research (ICAR) and the State Agricultural Universities (SAUs), along with the CGIAR institutes that are actively engaged internationally in tackling the FAW challenge, like CIMMYT, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and others, need to come together to effectively address the issue.

In collaboration with technical partners, FAO of the United Nations has established the Fall Armyworm Monitoring and Early Warning System (FAMEWS), which consists of the FAMEWS mobile app that was deployed in March 2018, and a global platform that was launched in July 2018. The mobile app is now available in 13 languages and can be downloaded from the Google Play Store in this link:https://play.google.com/store/apps/details?id=org.fao.faw. Progress has also been made on FAW environmental suitability models that can help the prioritization and optimization of scouting and trapping activities.

Integrated Pest management (IPM)

Many organizations, including both public and private sector, have been intensively working on identifying/validating/developing technologies and management practices that can help manage the FAW in Africa, as well as for creating awareness among the stakeholders on IPM-based FAW control. The experiences and lessons learnt so far could be very valuable to India in effectively tackling the pest incidence.

From the experience so far, it is clear that there is no single solution for sustainable management of FAW in Africa or Asia. We need to have a science-based, inclusive and well-balanced IPM strategy.

An effective IPM strategy for control of FAW will employ host-plant resistance, biological control, cultural control, and environmentally safer synthetic and bio-pesticides to protect the crops from economic injury while minimizing negative impacts on people, animals, and the environment. USAID Feed-the-Future and CIMMYT have jointly released "Fall Armyworm in Africa: A Guide for Integrated Pest Management". This publication could serve as an initial basis for decision making and strategic planning in India.

National research systems of many countries in the North and South America as well as international organizations like CIMMYT, have already designed the right mix of approaches to contain the pest below economic threshold level (ETL). With increasing awareness on correct pesticide usage (use chemicals ONLY when the pest load has crossed the ETL), effective pesticide management is all the more important. Scientists of NARES may come out with appropriate protocols, including lists of environmentally safer and effective pesticides which are compatible with the IPM strategy.

Evidence-based Control: Mechanical and cultural control practices against FAW should be promoted in the affected States in India, as the FAW problem is still localized. As mentioned earlier, the female moth of FAW lays up to 1500 eggs a month. These eggs are discernible to naked eyes and therefore, with proper training, farmers can recognize and destroy these egg masses so as to prevent the caterpillars from destroying the crops. Landscape management approaches and cultural practices which have already been tried for FAW and other pests could be validated and up-scaled. Scientists should also come out with specific recommendations based on principles of agro-ecological control.

Host plant resistance: It is a central component of the IPM strategy to control FAW. FAW tolerant/resistant varieties, whether derived through naturally occurring "native" genetic resistance or through transgenes, provide practical and economical ways to minimize losses to the pest. Host plant resistance is also quite compatible with other IPM-based control methods and often shows synergistic effects with insecticides and natural enemies. Most native resistance in maize to FAW is polygenic (based on multiple genes) and quantitative in nature, conferring "partial resistance". Throughout the 1970s to 1990s, research conducted at CIMMYT in Mexico, EMBRAPA in Brazil, USDA-ARS (Mississippi), University of Florida, and USDA-ARS Germplasm Enhancement of Maize (GEM) Program led to development of an array of improved tropical/sub-tropical/temperate maize inbred lines with at least partial resistance to FAW. This indicates that there is good genetic variation and high potential to support breeding for resistance to FAW. The quantitative or polygenic nature of native genetic resistance also offers the opportunity to minimize selection pressure on FAW, and prevents emergence of new resistant strains.

Genetically modified crop: Deploying transgenic or genetically modified (GM) crop varieties that express lepidopteran resistance genes could also be another strategy to effectively control FAW damage in maize. Several different *cry* genes are available—e.g., *cry1A, cry1Ab, and cry1F*—and have been exploited in commercial *Bt* maize varieties globally for over 20 years. In addition, Bt produces another class of lepidopteran-specific proteins termed Vegetative Insecticidal Proteins (VIP). These VIPs are encoded by *vip* genes, the most notable of which is the *vip3A* gene used to confer FAW resistance. Numerous GM maize hybrids, including various combinations of *cry* and *vip* genes, are commercially available in Brazil and North America, where over 80% of the total maize production area is cultivated with *Bt* maize.

Institutions: Public and private sector institutions must coordinated to develop elite crop varieties that combine resistance to FAW with other desirable and relevant traits for smallholder farmers. Breeding for tolerance/resistance to FAW is feasible by using native genetic resistance and/or transgenic resistance. Though genetically modified (GM) varieties may face additional regulatory and consumer acceptance hurdles, maize varieties carrying lepidopteran-specific transgenes provide significant protection against FAW, and could be be an important tool in the IPM tool box.

Biological control: It is an important component of an IPM strategy against many major crop pests in India and elsewhere. Quick identification and validation of biological agents, such as parasitoids, predators and entomopathogens, against FAW, and wherever possible, release of well-validated bio-pesticides should be taken up as a priority item by NARES in India. Biopesticides are generally considered to be a categorically lower risk option and can be a highly effective alternative to FAW management. Biopesticide products are based on pathogens of the pest (bacteria, baculoviruses, fungi, and entomopathogenic nematodes), but may also be taken to include other biologically based products such as plant extracts (botanicals), biochemicals with various modes of action, and even predators and parasites (macrobials). When used in conjunction with good crop management they can help to keep pest levels under control, reducing the need to apply synthetic pesticides. The supply-chain of the biological control agents for FAW management, and continuous training of the farmers and extension personnel, would be key to success of biocontrol-based IPM strategies. Some biopesticides are already registered in India, but their efficacy against FAW needs to be systematically validated before potential deployment. Once validated, biopesticides would offer safer alternative to chemicals as they generally have a much narrower

target spectrum than most chemicals and do not pose the same health risk to spray operators, wildlife and the environment.

Pesticide risk management is an important aspect. Pesticides in current use against FAW have been classified according to hazards and risks. Proposed criteria for pesticide recommendations include selecting those materials that may be used with minimal protective clothing (PPE), and which allow re-entry to the field, one day or less after application. Pesticides of biological origin and living agents was comprehensively reviewed and a guide to candidate FAW bio-pesticides and biological control agents has been published.

We must recognize that FAW being a polyphagous pest, it can attack a host of crop plants as high as 80%. Therefore, ICAR and CGIAR institutes like CIMMYT and ICRISAT which have a vast array of germplasm in their Gene Banks and also, varieties that could be tested for native genetic resistance to the FAW need to work together intensively. Molecular biological tools now offer great scope to accelerate development of new and promising varieties that could offer tolerance/resistance to FAW and a host of other biotic stresses. This is a medium- to long-term strategy and requires effective coordination and resources from the Indian Government (as well as host country Governments in the FAW-affected nations in Africa), donors, and the private sector. A well thought-out research and development coupled with global partnership is the need of the hour for jointly benefiting from such efforts and to safeguard the interests of the small farmers from serious threats such as FAW.

Agro-ecological approaches: Sustainable soil and land management practices, and diversification through inter-cropping, crop rotation, agroforestry, and management of semi-natural habitats at multiple spatial scales, could potentially offer culturally appropriate pest control strategies for smallholders. These can be readily integrated into existing efforts to improve farmer incomes and resilience through sustainable intensification and climate-smart agriculture. However, the efficacy of agro-ecological measures for reducing FAW impact, and the costs of these measures, need to be assessed across environmental and socio-economic contexts.

Collective Action through a Fall Armyworm R&D International Consortium

CIMMYT and IITA (International Institute on Tropical Agriculture) have recently initiated the "Fall Armyworm R&D International Consortium". The Consortium brings together more than 35 different institutions worldwide, including North America, South America, Europe, Africa, and Asia, and from the public and private sectors, to explore ways to synergistically work on short, medium, and long-term solutions to tackle the challenge of FAW in Africa, and in other parts of the world where the pest is prevalent. ICRISAT, the only CGIAR center headquartered in India has already offered its willingness for this global network for identification/validation and development of suitable technologies/management practices against the FAW. ICAR, having one of the largest pools of scientific talents in the world, is also expected to join hands in this important initiative to prevent FAW from becoming a potential threat for major crops to the smallholders in India, as well as in other countries in Asia.

In a changing climate and global connectedness through trade and tourism, invasive pest attacks could become more frequent than ever before. Wherever possible, we need to step up our phytosanitation and quarantine efforts to prevent the onset of transboundary pathogens/pests. Effective monitoring, surveillance and early warning systems, coupled with capacity to quickly respond to any new insect-pest threat through IPM, are vital for safeguarding the crops and to protect the income and livelihoods of the smallholders that dominate the Asian agrarian landscape. India must fail the spread of the pests like Fall Armyworm in the beginning itself through proactive and collective inter-institutional and multi-disciplinary efforts.

[1]Director, Country Relations at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), New Delhi, [2]Director CGIAR Research Program MAIZE, and Global Maize Program, International Maize and Wheat Improvement Center (CIMMYT), Nairobi, Kenya. Corresponding authors' e mail: A.Padhee@cgiar.org