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EDITORIAL

The fall armyworm: recent advances in biology and management

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The fall armyworm (FAW), *Spodoptera frugiperda* (JE Smith, 1797) (Lepidoptera: Noctuidae), is known to feed on more than 350 plant species, including those that are important sources of food (e.g., sorghum, rice, and maize), fiber (e.g., cotton), and fodder (e.g., grasses). A native pest of the Americas, this pest recently invaded many parts of Africa, Asia, and Australia and is knocking on the doors of Europe. Several unique features, including high mobility, polyphagous feeding habits, a highly effective detoxification system enabling the development of resistance to insecticides and plant toxins, and behavioral and physiological plasticity, make this pest difficult to manage. Therefore, the current management practices are inadequate to deal with sudden outbreaks of FAW. The farmers in these countries are using various options such as biological control agents, mechanical control, natural products, chemical insecticides, pest tolerant crops, and indigenous methods to manage this pest (Fig. 1) (Kenis et al. 2023). While these efforts may work short term to control this invasive pest, concerted research is urgently needed to develop highly effective methods to manage this pest. Indeed, there is an increase in research efforts on the biology and management of FAW. In that respect, this special issue on fall armyworm biology and management is timely and contains 24 papers, including one review focused on this invasive pest.

When a pest invades new areas, identifying and deploying biological control agents are often used to prevent the spread and damage and sometimes even to eradicate the pest (Asplen et al. 2015; Desneux et al. 2022; Gugliuzzo et al. 2021; Giovannini et al. 2022). There have been extensive research efforts in this area on FAW parasites, predators, and pathogens in the countries where FAW recently invaded. This issue includes papers focusing on the biological control of FAW on a variety of topics, including egg and larval parasitoids, cannibalism, and intraguild predation (Agboyi et al. 2023; Chen et al. 2022a; Chen et al. 2022b; Li et al. 2023; Sokame et al. 2022), comparative effects of biopesticides (Agboyi et al. 2023), and development of recombinant baculoviruses (Bai et al. 2023). In some areas of Africa and Asia, all kinds of materials, including biopesticides (Koffi et al. 2023), Brewery's hop (Yoon and Tak 2023), chlorantraniliprole emulsified with botanicals (Song et al. 2023), entomopathogenic nematodes, fungi, bacteria, and even rabbit urine, are being unitized to manage this pest. Papers included in this issue revealed that food attractants could be used to monitor and forecast FAW seasonal abundance (He et al. 2023), Sorghum and maize flavonoids are detrimental to the growth and survival of FAW (Chatterjee et al. 2022), and push–pull plants in the wheat intercropping system could be used to manage this pest (Liu et al. 2022).

It is important to understand the behavior of invasive pests in the newly invaded environment. Three papers on this issue report on leaf-borne vibratory stimuli and behavioral responses (Turchen et al. 2022), the effect of invasive FAW abundance on native species (Wu et al. 2022), and assessing the risk of establishment and transient populations of FAW in Europe (Gilioli et al. 2022). As stated above, resistance developed by FAW to insecticides and plant toxins is considered one of the factors contributing to the spread of FAW populations worldwide. Five papers report on recent developments in this area, including modeling FAW resistance in *Bacillus thuringiensis* toxin expressing maize areas (Tomé et al. 2022), FAW resistance in Bt-maize areas of China (Wang et al. 2022), identification of a P450 gene

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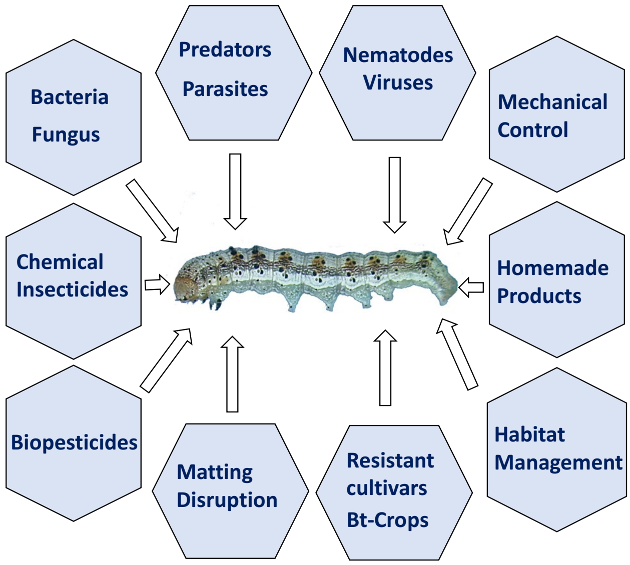

Fig. 1 Farmers in recently invaded countries by the fall armyworm (FAW), *Spodoptera frugiperda*, are using multiple integrated pest management tools and approaches

that contributes to deltamethrin resistance (Chen and Palli 2022b), studies on ace1 and ace2 roles in insecticide sensitivity (Gao et al. 2023), and fitness costs associated with spinetoram resistance (Kanno et al. 2023).

Both genome and transcriptome sequences for FAW and cell lines derived from this insect have been completed. However, research on developmental and physiological processes at the molecular level and functional genomics are not well-advanced in this pest. RNA interference (RNAi) discovered 25 years ago in the nematode works well in coleopteran and other insects and helped to advance functional genomics research in pest insects (Zhu and Palli 2020). Unfortunately, RNAi is not efficient in FAW due to the presence of highly effective dsRNases in the lumen, entrapment of dsRNA in the endosomes, and the absence of critical players (e.g., StaufenC) (Shukla et al. 2016; Yoon et al. 2018). Genome editing technologies, especially the CRISPR/Cas9 method, may help knock out genes in FAW and advance functional genomics research (Zhu et al. 2020). The impact of host plants on biological characteristics and Vitellogenin/Vitellogenin receptor expression (Han et al. 2022) and transgenerational effects of thermal stress on reproductive physiology (Reshma et al. 2023) are described in these papers on the biology of FAW. Chen and Palli (2022a) describe multiple transgenic CRISPR/Cas9 methods developed to facilitate functional genomics studies in FAW. The papers included in this special issue and research in progress in many laboratories around the world on biology and management of FAW will likely lead to better management methods reducing crop losses and improving food security.

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