

Review Article

Distribution, Epidemiology, Economic Importance and Management of Fall Armyworm *Spodoptera frugiperda* (J E SMITH) on Maize Production in Ethiopia

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Abstract

Since its first detection in 2017, the Fall Armyworm (*Spodoptera frugiperda* J.E. Smith) has become one of the most damaging pests threatening Ethiopian maize output. This invasive pest presents considerable issues due to its quick spread, strong reproductive capacity, and adaptation to a variety of agroecological zones. The current study summarizes research findings from 2019 to 2025 on FAW distribution, epidemiology, economic impact, and management techniques in Ethiopia. FAW is currently found in all major maize-growing regions, with infection rates affected by climatic factors, cropping patterns, and agroecological conditions. Economically, FAW produces yield losses ranging from 20% to over 70%, with serious consequences for smallholder farmers' livelihoods and national food security. Cultural practices (early planting, crop rotation, intercropping), mechanical control (handpicking, trapping), biological control (parasites, predators), botanical insecticides (neem extracts), entomopathogens (fungal and bacterial agents), host plant resistance (the development of tolerant maize varieties), and chemical control (insecticide application) have all been investigated and implemented. Integrated Pest Management (IPM) techniques that combine these strategies have shown the greatest potential for long-term control. However, difficulties such as low farmer awareness, insufficient extension services, pesticide resistance, and a lack of bio-pesticide infrastructure impede effective management efforts. This analysis emphasizes the importance of increased research, farmer training, policy assistance, and multi-stakeholder collaboration in order to improve FAW control and safeguard Ethiopia's maize output. Adoption of IPM adapted to local contexts remains crucial for minimizing FAW consequences and preserving agricultural resilience in the face of this ongoing threat.

Keywords

Fall Armyworm, *Spodoptera Frugiperda*, Maize Production, Pest Management, Integrated Pest Management (IPM)

1. Introduction

Maize (*Zea mays* L.) is a critical component of Ethiopian food and livelihood security, providing both a staple meal and a source of income for millions of smallholder farmers. It is one of the most frequently farmed grains in the country,

adding significantly to national grain production and playing an important role in reducing malnutrition and poverty, particularly in rural regions [12, 10]. However, in recent years, maize production in Ethiopia has been seriously hampered by

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the invasion of the Fall Armyworm (*Spodoptera frugiperda* J.E. Smith), an alien pest species originally to the Americas that has established itself as a major danger across Africa.

Fall Armyworm (FAW) was first discovered in Ethiopia in 2017 and has rapidly spread throughout the country, affecting nearly all maize-growing regions, including Oromia, Amhara, Tigray, Benishangul-Gumuz, and the Southern Nations, Nationalities, and Peoples' Region [15, 16]. FAW is a migratory and polyphagous pest that may feed on over 80 plant species, with maize being its favorite host [7]. Its aggressive feeding behavior, rapid reproduction rate, and adaptation to a variety of environmental circumstances make it exceptionally challenging to manage, particularly in countries like Ethiopia where pest monitoring and response systems are frequently weak [5, 1].

FAW's biology and ecology have a considerable impact on its invasiveness. In tropical and subtropical climates like Ethiopia, FAW can produce many generations per year, with overlapping life phases and no need for diapause, allowing for ongoing population growth and persistence [12]. Adult moths are excellent fliers, capable of traveling hundreds of kilometers in a short period of time, allowing them to spread throughout various agroecological zones. The insect thrives in the majority of Ethiopia's maize-growing areas due to favorable climatic circumstances such as moderate to high temperatures and extended rainfall periods.

The economic consequences of FAW infestations are significant. According to studies, unchecked infestations can cause production losses of up to 100% under severe attack, depending on the crop growth stage and the effectiveness of management measures used [6, 9]. In Ethiopia, national yield losses from FAW are projected to be 20-50% per year, considerably decreasing household incomes and leading to food insecurity [2, 16]. For smallholder farmers, who rely largely on maize for food and money, these losses, are catastrophic, especially in years of severe infestation and insufficient response capacity. In addition to direct yield losses, indirect economic consequences include increased pesticide spending, reduced investment in other agricultural inputs, and lost market possibilities due to poor grain quality [14].

Ethiopia's efforts to manage FAW have been complex, yet they are still fragmented and insufficient. The Ethiopian government, in partnership with international organizations such as the Food and Agriculture Organization (FAO), implemented emergency response tactics like as surveillance, awareness campaigns, and insecticide delivery. However, these initiatives were frequently reactive rather than proactive, and they lacked sustainability [5, 15]. Furthermore, many smallholder farmers confront financial and logistical challenges to obtaining effective pest management methods and information.

Recent research has highlighted the importance of an Integrated Pest Management (IPM) approach in combating FAW on a long-term basis. This comprises a variety of ap-

proaches, including timely planting, crop rotation, biological management with parasitoids and entomopathogens, botanical use, resistant maize cultivars, and enhanced farmer training [2, 10]. *Telenomus Remus* and *Trichogramma* spp., for example, have showed promise in lowering FAW populations in the field, however large-scale implementation remains difficult [15]. Similarly, the creation and distribution of locally adapted FAW-tolerant maize varieties such as BH-546 and BH-661 is gaining traction, though adoption rates remain low due to restricted seed availability and farmer education.

Understanding the prevalence, epidemiology, and economic effects of FAW, as well as the strengths and limits of current management measures, is critical for developing context-specific solutions. This becomes even more serious in light of climate change, which may facilitate the spread and establishment of FAW in new Ethiopian regions [12, 13]. The pest's adaptability and rapid evolution necessitate an integrated, collaborative, and science-based approach that fills information gaps and connects national policy with local realities. A comprehensive evaluation of current research can assist in identifying effective interventions and making actionable suggestions to stakeholders at all levels.

Thus, the purpose of this study is to integrate and critically assess research findings from 2019 to 2025 on the distribution, epidemiology, economic effect, and control techniques of *Spodoptera frugiperda* in Ethiopia. The assessment will identify important trends and problems, evaluate the effectiveness of current control strategies, and make evidence-based suggestions to ensure long-term maize production in the face of FAW threats.

2. Literature Review

2.1. Distribution of Fall Armyworm in Ethiopia

Spodoptera frugiperda, as known as the Fall Armyworm (FAW), has rapidly infested significant maize-growing areas across Ethiopia since its official discovery in 2017. Early studies by the Ministry of Agriculture and partners such as FAO reported that the pest had spread to over 300 districts across the country within a year, particularly in the Oromia, Amhara, SNNPR, Benishangul-Gumuz, and Tigray areas [4, 15]. FAW's rapid and widespread dissemination was attributed to its excellent migratory capacity, reproductive potential, and adaptability to various agro-ecologies [7, 16].

Ethiopia's climatic conditions, particularly in the mid- and low-altitude zones where maize is farmed, are ideal for FAW growth and spread. According to studies, temperature and relative humidity have a significant impact on FAW life cycles and epidemic intensity [12, 13]. According to [3], surveillance efforts have proven FAW's year-round persistence in warm, irrigated areas, with seasonal outbreaks occurring during the main (Meher) cropping season in rain-fed systems.

In addition to natural circumstances, the pest's spread has been aided by ongoing maize planting throughout agroecologies and lax border quarantine procedures. The lack of integrated regional monitoring and early warning systems exacerbated the situation, especially in the early years of invasion [5, 14]. As a result, FAW is currently among the most harmful pests of maize in Ethiopia, drastically decreasing national food security.

2.2. Epidemiology and Outbreak Patterns

FAW's epidemiological success in Ethiopia is partly due to its flexible life cycle, which allows for many generations per year without diapause. The pest can complete its life cycle in as little as 30 days under ideal conditions (20-30 °C), allowing for fast population increase [12, 15]. Its eggs, larvae, and adults have good survival rates, and the adult moth may fly over 100 kilometers each night, explaining the rapid regional spread seen since 2017 [1].

In addition, studies have identified major environmental and agronomic elements influencing FAW outbreaks. Discovered that FAW was most common in areas with moderate rainfall and long maize-growing seasons [16]. Continuous maize farming (particularly under irrigation) in lowland areas such as Oromia and SNNPR feeds the pest all year, transforming such places into breeding reservoirs. Furthermore, poorly timed control applications, delayed planting, and a lack of crop rotation produce ideal conditions for infestation [13, 2]. While pheromone trap networks have been implemented in a few regions, a lack of systematic, national monitoring still hinders outbreak prediction and containment [6]. Local adaptation studies are currently underway to better understand FAW behavior in various Ethiopian ecologies, but additional research is required to construct predictive epidemiological models [10].

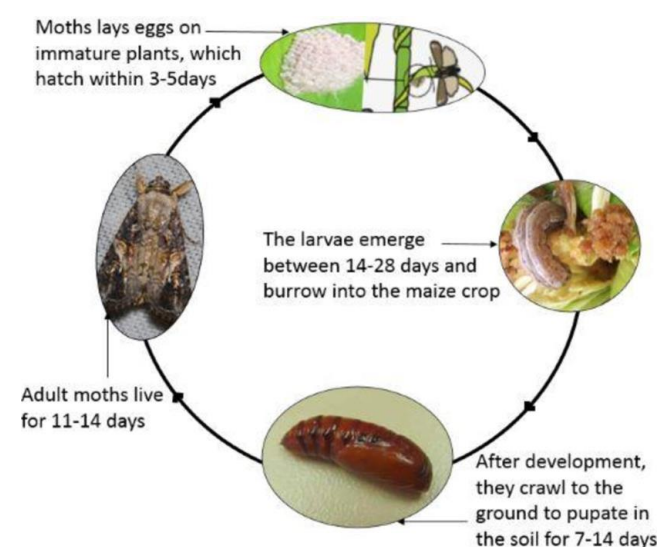


Figure 1. Life cycle of fall armyworm (*Spodoptera frugiperda*) on maize, showing egg laying, larval emergence, pupation, and adult moth stages [1].

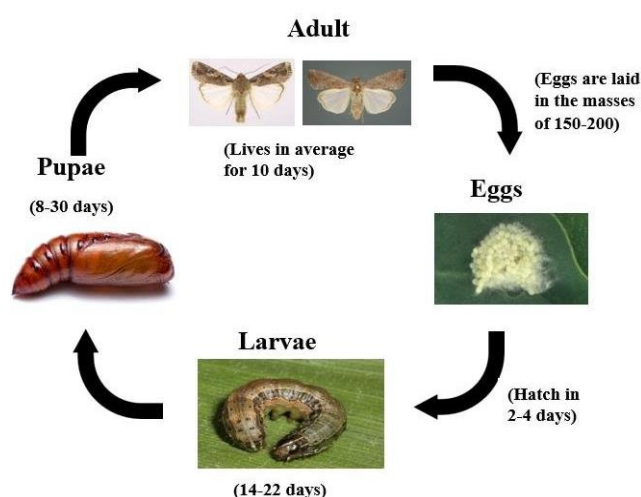


Figure 2. Developmental stages of *Spodoptera frugiperda*, showing its life cycle from egg to adult moth, including egg hatching (2-4 days), larval feeding (14-22 days), pupation (8-30 days), and adult lifespan (~10 days) [2].

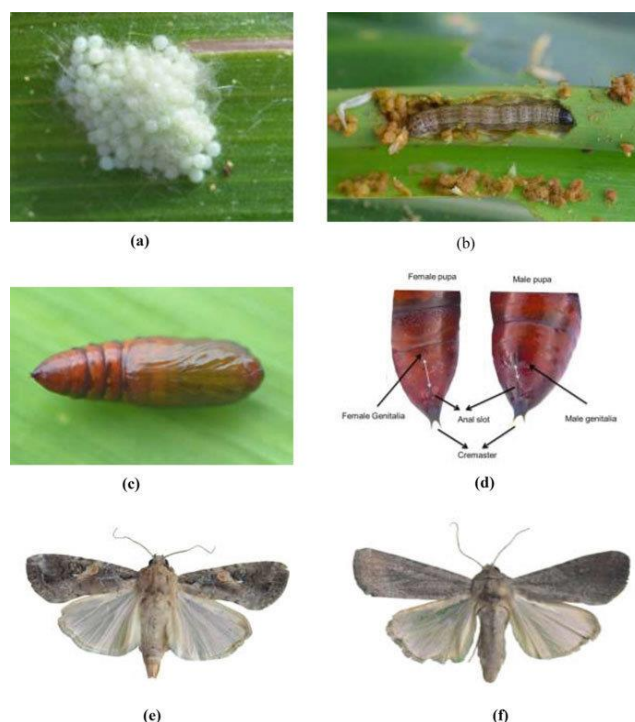


Figure 3. Morphological development stages of *Spodoptera frugiperda*: (a) egg mass, (b) early larva, (c) pupa, (d) male and female pupal genitalia differentiation, (e) female adult moth, and (f) male adult moth [3].

2.3. Economic Importance and Impact on Maize Production

FAW has an indirect and direct impact on maize productivity. The larval stage actively feeds on maize leaves, whorls, tassels, and ears, resulting in severe defoliation and photosynthesis disruption. Yield losses from FAW vary according to infestation stage, treatment strategies used, and local con-

ditions, ranging from 15% in well-managed fields to more than 70% in neglected areas [14, 9]. Extreme occurrences of crop failure have been observed, notably in western Ethiopia.

According to [1], Ethiopia lost approximately 750,000 metric tons of maize in 2020 alone owing to FAW, at an economic loss of more than USD 250 million. Smallholder farmers, who account for more than 90% of maize production, are disproportionately affected. To avoid re-infestation, many farmers have purchased emergency pesticides, reduced other important inputs, and reduced planted acreage in succeeding seasons [16]. During FAW outbreak years, families in some places experienced food shortages and higher maize prices, demonstrating the disease's considerable socioeconomic impact [10]. FAW has also damaged Ethiopia's agricultural reform strategy, notably measures targeted at increasing maize production. Its emergence has posed significant hurdles for national extension agencies, which were not prepared to deal with such a fast-moving and complicated pest [15].

2.4. Economic Impacts of Fall Armyworm on Maize Production in Ethiopia

2.4.1. Direct Economic Losses

The Fall Armyworm (FAW), *Spodoptera frugiperda* J.E. Smith, is a severe insect that threatens maize production in Ethiopia. Since its discovery in 2017, FAW has caused significant crop damage, with production losses projected to surpass 36% in heavily infested areas [15, 2]. These direct economic losses result in lower income for farmers, higher production costs, and increasing food insecurity in vulnerable locations.

FAW larvae feed voraciously on maize leaves, tassels, and ears, significantly reducing photosynthetic efficiency and grain yield [11]. In Ethiopia, where maize is a main food crop and a major source of income, the consequences are especially severe. Maize yield losses impair not just household food availability but also national grain reserves, impacting both subsistence and market-oriented agricultural systems [16].

High infestation rates increase farmers' reliance on chemical insecticides, raising production costs and posing health and environmental dangers [14]. Furthermore, repeated pesticide usage promotes the development of insecticide resistance in FAW populations, increasing control costs and decreasing the efficacy of chemical interventions [8]. Investment in research and extension services is critical for improving pest management, reducing crop losses, and ensuring food security. Governments and development partners must prioritise the development and dissemination of low-cost, long-term pest control techniques to assist smallholder farmers and strengthen food systems against future outbreaks.



Figure 4. Damage of *S. frugiperda* on a maize plant in fields' main cropping season [11].

2.4.2. Indirect Economic Effects

FAW's indirect economic effects are numerous, affecting the entire agricultural sector and food supply networks. Reduced maize production raises market prices, limiting access to low-income customers and contributing to food inflation [4]. These implications jeopardize national food security and disproportionately harm impoverished households that rely on maize as a staple. FAW infestations also interfere with seasonal planning and farm labor allocation. Farmers may quit afflicted fields or switch to less impacted crops, changing cropping patterns and decreasing land use efficiency [15]. Furthermore, relying on imported pesticides diverts national resources and increases vulnerability to global supply shocks.

The environmental and health costs associated with excessive insecticide use are another layer of indirect economic loss. Pesticide exposure has been linked to acute health problems among Ethiopian smallholders, especially in areas lacking protective equipment and training [16]. These issues underscore the urgent need to adopt ecologically safe and socially acceptable control measures. Long-term, agro ecosystem damage caused by unsustainable FAW control practices can reduce resilience to future pest invasions, droughts, and climate-related shocks [2]. Thus, addressing FAW necessitates not just technical solutions, but also institutional cooperation and long-term investments in sustainable agriculture.

2.4.3. Impact on Farmers' Livelihoods

Ethiopian maize farmers' livelihoods are especially sensitive to the economic shocks generated by FAW infestations. Smallholders frequently operate on tight margins, and the sudden loss of a major percentage of their harvest can plunge families into food insecurity and poverty [10]. Many small-scale farmers lack the necessary technical skills and financial means to purchase and use approved insecticides. Others rely on subpar or mishandled chemical goods, resulting in poor control results and wasted resources [14]. This capability gap further marginalizes resource-poor farmers and exacerbates rural inequality.

Training programs that promote Integrated Pest Management (IPM) and sustainable practices are critical for improving farmers' resilience. Educational outreach, particularly through farmer field schools and extension services, can help communities detect FAW, implement early interventions, and reduce crop losses [1].

The development of indigenous maize landraces and resilient cultivars provides an opportunity to maintain farmers' livelihoods. According to research, some local cultivars have innate resistance features that can help prevent FAW harm. Incorporating these landraces into formal breeding programs has the potential to improve genetic diversity and crop resilience over time. Support for farmer cooperatives and community-based pest management groups can also improve access to resources and knowledge-sharing platforms, fostering collective resilience in the face of pest outbreaks.

2.5. The Role of Integrated Pest Management and Sustainable Strategies

Integrated Pest Management (IPM) provides a comprehensive approach to addressing FAW's complicated economic concerns. IPM increases sustainability by integrating cultural practices, biological control agents, resistant cultivars, and judicious chemical use.

Biological control, particularly through natural enemies such as *Telenomus remus* and *Trichogramma* spp., has demonstrated potential in Ethiopian settings. According to research, these parasitoids can considerably lower FAW egg and larval populations, thereby reducing the requirement for chemical insecticides [2]. Field trials have shown that using these compounds within IPM systems not only reduces pest populations but also promotes biodiversity and environmental health [16].

Botanical insecticides, such as neem-based formulations, provide low-toxicity, locally available alternatives to synthetic chemicals. In Ethiopian experiments, neem extracts were found to be effective against FAW larvae, making them especially useful for smallholders who cannot afford imported products. Agro-biodiversity, such as intercropping and crop rotation, improves ecosystem resilience while suppressing pest populations by disturbing host plant continuity [3]. Such measures also promote habitat conditions that are conducive to natural enemies, hence increasing biological control. Climate-smart agriculture methods, such as drought-tolerant and pest-resistant varieties, early planting, and water-saving practices, can help maize systems withstand both FAW and climate change impacts [8]. Integrating these approaches into FAW management can save input costs, boost production, and increase food system sustainability.

2.6. Policy and Institutional Recommendations

Addressing the economic consequences of FAW necessitates strong institutional and policy backing. National policy

should encourage widespread use of IPM, increase local bio-pesticide production, and improve farmer access to better maize varieties [14]. Investing in research and development is crucial for advancing biological control technologies, discovering novel resistant maize lines, and improving early warning and monitoring systems [10]. Partnerships between governments and foreign research organizations can help to accelerate the implementation of science-based solutions. Extension services must be empowered to provide farmer-centered pest management instruction and demonstrations, bridging the knowledge gap between scientific innovation and practical application [2].

2.7. Management Strategies in Ethiopia

Ethiopia's FAW management has shifted from emergency reaction to more integrated plans. Initially, the government and development partners delivered chemical insecticides such as chlorpyrifos, lambda-cyhalothrin, and emamectin benzoate to impacted farmers [4, 12]. While synthetic insecticides are helpful in early infestations, misuse has been linked to resistance development and negative environmental effects.

More recently, focus has shifted to Integrated Pest Management (IPM), which includes biological control, cultural practices, host plant resistance, and pesticide minimization. The use of biological control agents such as *Telenomus remus* and *Trichogramma chilonis* has showed potential in field experiments, but it remains underutilized due to poor mass manufacturing and distribution infrastructure [2].

Entomopathogens such as *Metarhizium anisopliae* and *Beauveria bassiana* have also been tested and demonstrated modest success in Ethiopian settings [15].

Cultural measures such as early planting, maize intercropping with legumes, field sanitation, and egg mass destruction are advised but not widely implemented. Farmer knowledge is still inadequate, and access to training materials is variable [16]. Furthermore, efforts are underway to produce and distribute FAW-resistant maize varieties, such as BH-546 and BH-661, although seed availability, price, and acceptance remain low [11, 10]. Efficient management of FAW necessitates multi-stakeholder coordination, integrating government-led policy frameworks with farmer-level extension, research innovation, and private sector investment. Without such coordination, FAW is likely to remain a persistent limitation on maize productivity in Ethiopia.

Cultural Control

Cultural control refers to agronomic measures that try to make it difficult for FAW to survive and reproduce. Early planting, crop rotation, intercropping, and field sanitation are the most commonly recommended strategies [1, 16]. Coordinating planting time minimizes vulnerability to early infestations by reducing overlap between sensitive maize stages and peak FAW numbers [12]. Farmers in Ethiopia who planted early reported lower FAW incidence, which they attributed to pest population dynamics and natural mortality [15].

Rotating maize with non-host crops, such as legumes, and intercropping with Desmodium or beans, can disrupt FAW oviposition and larval development by limiting food availability and creating homes for natural enemies [3, 2]. However, adoption is still modest due to typical monoculture preferences and low knowledge. Field sanitation, such as removing infested crop residues, alternate host plants, and volunteer maize plants, can diminish FAW breeding sites [16]. Although beneficial, labor constraints prevent widespread implementation, particularly during high seasons. Despite their environmental safety and cost-effectiveness, cultural controls alone sometimes provide only partial FAW reduction and should be used in conjunction with integrated frameworks [12].

Push-Pull Technology for Fall Armyworm Management in Maize

Push-pull technology is an excellent pest control method in crops like maize, including the Fall Armyworm (*Spodoptera frugiperda*). The technique works by having maize intercropped with Desmodium, which emit volatiles repelling moths ("push"), and trap plants such as Brachiaria or Napier grass surround the field that lure and then trap the pests ("pull"). Besides reducing pest populations and damage to plants, the system improves soil fertility, suppresses parasitic weeds such as *Striga*, and therefore enhances crop productivity [17, 18]. Given its environmentally friendly and sustainable nature, the technique is a great choice for smallholder farmers in sub-Saharan Africa.

Recent research advancements reveal the utility of drought-tolerant Desmodium and Brachiaria varieties, capable of making the push-pull technology applicable to various agroecological zones. Between 2018 and 2024, research conducted in Kenya and Ethiopia showed that pest infestation was lower and crop yield significantly higher in those farms that applied the push-pull control technology than those practicing conventional methods [19, 20]. More than just keeping pests away, the push-pull way helps the whole farm world by adding to life variety, making soil better, and cutting down on fake add-ins. This makes it a strong and weather-wise way to keep farming good and lasting.



Figure 5. Schematic Representation of the Push-Pull Technology for Fall Armyworm (*Spodoptera frugiperda*) Management in Maize Production [17], [18], [19], and [20].

Mechanical Control

Mechanical control methods lower pest numbers by physically removing or destroying FAW life stages. These strategies are most effective at the smallholder level, where labor is abundant. Handpicking egg masses and larvae has been shown to lower infection intensity in Ethiopian villages [1]. However, this method is labor-intensive and less viable for big areas. Traps: Pheromone and light traps are used for monitoring and population control. Pheromone traps attract adult male moths, which helps with population observation and intervention timing. While largely used as monitoring tools, mass trapping has had mixed results [16].

Biological Control

To suppress FAW populations, biological control uses natural enemies such as parasitoids, predators, and pathogens. Ethiopia has investigated and promoted a number of biological agents for pest management that are environmentally friendly. The egg parasitoid *Telenomus Remus* is a well-studied and introduced natural enemy in Ethiopia [11, 2]. Field releases have resulted in high egg parasitism rates, reducing larval emergence and damage. Native parasitoids such as *Chelonus* spp. and *Cotesia* spp. also help to regulate FAWs naturally, though their abundance varies by region [15]. Generalist predators like ladybird beetles (*Coccinellidae*), lacewings (*Chrysopidae*), and spiders have been found to feed on FAW eggs and larvae [16]. Increasing habitat diversity by intercropping and reducing pesticide use benefits predator populations. Research suggests that using *Beauveria bassiana*, *Metarhizium anisopliae*, and *Bacillus thuringiensis* (Bt) can effectively combat entomopathogenic fungi and bacteria in Ethiopia [12, 15]. These chemicals infect and destroy FAW larvae, providing an environmentally acceptable alternative to chemical pesticides. However, mass production, formulation, and delivery systems require additional development. Biological control is seen as a critical component in FAW management, enhancing ecological balance and lowering dependency on pesticides [2].

Botanical Control

Botanical insecticides generated from insecticidal plants provide locally accessible and environmentally friendly options for managing FAW.

Neem (*Azadirachta indica*): In Ethiopia, neem extracts and formulations shown larvicidal and antifeedant properties against FAW [12]. [16] found that neem oil application reduced larvae survival and feeding damage in a manner comparable to synthetic insecticides. Plants like *Lantana camara*, *Ocimum basilicum*, and *Eucalyptus globulus* have been evaluated for insecticidal activity against FAW with varying efficiency [15]. Adoption is hampered by the inconsistency of raw material supply and the absence of defined extraction processes. Botanical control approaches are especially beneficial for resource-poor farmers since they are less toxic and have a lower environmental impact, but they require better formulation and extension support [1].

Entomopathogens

Entomopathogens are bacteria, fungi, and viruses that infect and kill insects. Ethiopia has made achievements in the study of entomopathogens as bio-pesticides against FAW. Fungal pathogens, including *Beauveria bassiana* and *Metarhizium anisopliae*, have been found to be pathogenic in FAW larvae in both lab and field settings [12, 15]. These fungi penetrate the insect cuticle and kill it within days.

Bacillus thuringiensis (Bt) is a popular insecticide that produces crystal proteins that are harmful to lepidopteran larvae. It has been studied in Ethiopia. Bt formulations have been shown to cause substantial larval mortality and are being used in IPM programs [2]. Large-scale usage of these technologies is limited due to limitations in mass production, formulation stability, and application methods. Investment in local bio-pesticide production infrastructure is required.

Host Plant Resistance

The introduction of resistant or tolerant maize types provides a long-term, cost-effective way to reduce FAW damage. Ethiopian agricultural research organizations have created maize varieties resistant to FAW, including BH-546 and BH-661 [11]. These types' exhibit characteristics like as harder leaves, increased production of defensive compounds, and faster recovery from harm. Conventional breeding and molecular marker-assisted selection are expediting the production of better cultivars suitable for Ethiopian agro ecologies [10]. However, seed multiplication and dispersal remain constraints. Adoption Challenges: Low knowledge, limited seed availability, and farmer preference for local landraces hinder widespread adoption. Extension services, in conjunction with other management strategies, are critical for promoting resistant cultivars [2].

Chemical Control

Chemical pesticides have been Ethiopia's most effective and widespread FAW control technique.

Ethiopian farmers commonly use organophosphates (e.g., Chlorpyrifos), pyrethroids (e.g., Lambda-cyhalothrin), and newer compounds like Emamectin benzoate [4, 12] as insecticides. Chemical control can effectively lower FAW populations, but it comes with high costs, pesticide resistance, non-target impacts on natural enemies, environmental damage, and human health risks [14]. To manage resistance to pyrethroids and organophosphates, it's important to rotate and combine insecticides with other control methods [11]. Farmer Practices: Studies show that pesticides are misused and over-applied, mainly due to a lack of information and availability to safer alternatives [16].

2.8. Integrated Pest Management (IPM)

IPM uses a variety of compatible control strategies to produce effective, sustainable, and environmentally sound FAW management. Ethiopia has implemented an IPM framework that includes cultural practices, biological agents, host resistance, botanicals, and responsible chemical use [2,

15]. Early planting, biocontrol releases, resistant varieties, and targeted pesticide application in pilot projects have reduced FAW damage and input costs [11, 16]. To scale IPM, it is necessary to improve extension services, farmer education, supply chains for biocontrol chemicals and resistant seeds, and governmental support [10]. Remote sensing, pheromone monitoring, and community-based pest management platforms have the potential to enhance IPM implementation [14].

3. Conclusion and Recommendation

Since its discovery in 2017, the Fall Armyworm (*Spodoptera frugiperda* J.E. Smith) has become a widespread and devastating pest in Ethiopia's maize producing system. Its fast expansion over key agroecological zones is ascribed to its excellent mobility, climatic adaptability, broad host range, and ability to produce many generations each year. These biological features, along with conditions such as ongoing maize cultivation, insufficient early warning systems, and inadequate extension services, have resulted in widespread infestations. Yield losses in densely infested areas can exceed 50%, putting millions of Ethiopian smallholder farmers' food security and livelihoods at risk.

To mitigate the impact of FAW, a variety of management approaches have been proposed, including cultural practices (e.g., early planting, crop rotation), mechanical removal, biological control agents, botanical insecticides, entomopathogenic organisms, host plant resistance, and synthetic chemicals. Among these, Integrated Pest Management (IPM) stands out as the most sustainable, environmentally friendly, and financially viable option. Nonetheless, IPM implementation in Ethiopia is hampered by insufficient farmer knowledge, a paucity of inputs (e.g., resistant seeds, biocontrols), and a lack of coordinated stakeholder activity.

- 1) To boost FAW management and protect Ethiopia's maize sector, the following strategic proposals are proposed:
- 2) Expand and institutionalize IPM programs by incorporating farmer field schools, adaptive research, and community-based interventions.
- 3) Enhance early detection and monitoring systems with digital tools and pheromone traps to predict outbreaks.
- 4) Encourage local manufacture and distribution of effective biological and botanical insecticides.
- 5) Promote the development and spread of FAW-tolerant maize cultivars for varied agro ecologies.
- 6) Collaborate on national response activities with government authorities, research institutions, development partners, NGOs, and the commercial sector.
- 7) Improve farmer awareness and capability through continual training, demonstration plots, and information distribution via ICT and extension networks. Finally, creating a robust maize production system against FAW necessitates ongoing investment in research, innovation, policy support, and inclusive farmer engagement. A

comprehensive, knowledge-based pest management strategy is required in Ethiopia to prevent FAW damage, assure food security, and promote sustainable agriculture.

Abbreviations

FAW Fall Armyworm
FAO Food Agricultural Organization

Author Contributions

Dinku Atnafu Anega: Conceptualization, Methodology, Resources, Visualization, Writing – original draft

Zemed Wobale Birhane: Conceptualization, Methodology, Supervision, Visualization, Writing – review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

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