



Integrated Pest Management of *Helicoverpa armigera* (Hubner): A Sustainable Approach for Pest Suppression

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Helicoverpa armigera (Hubner) (Lepidoptera: Noctuidae), commonly known as the gram pod borer or cotton bollworm, is one of the most destructive and highly polyphagous insect pests of agricultural crops. The pest has a wide host range, high fecundity, considerable dispersal ability, rapid adaptability and the ability to develop resistance against insecticides. It attacks more than 180 plant species and causes serious economic losses in crops such as chickpea, pigeonpea, cotton, tomato, soybean, maize, sunflower and marigold. Larvae cause damage mainly by feeding on reproductive structures including flower buds, flowers, pods, bolls and fruits. The limitations of insecticide-dependent management, including resistance development, environmental contamination, destruction of natural enemies and increased production costs, emphasize the need for an integrated approach. Integrated Pest Management (IPM) combines cultural, mechanical, physical, biological and chemical methods with regular monitoring and economic threshold-based decision making. Cultural practices such as timely sowing, intercropping and trap cropping; mechanical methods such as pheromone trapping; biological control through parasitoids, predators and microbial agents and need-based application of selective insecticides can collectively suppress *H. armigera*. Studies presented in the seminar demonstrate that integrated modules can reduce larval populations and crop damage while improving yield and reducing dependence on chemical pesticides. Thus, IPM provides an effective, economical and environmentally sustainable strategy for the management of *H. armigera*.

Keywords: *Helicoverpa armigera*, integrated pest management, biological control, HaNPV, pheromone trap, marigold, economic threshold level, insecticide resistance

Introduction

Agricultural production is continuously threatened by insect pests, among which *Helicoverpa armigera* (Hubner) is considered one of the most important polyphagous pests. It belongs to the order Lepidoptera and family Noctuidae. The pest is widely distributed across Africa, Asia, Europe, Australasia and other regions and is particularly important in tropical and subtropical agricultural systems. The seminar material describes *H. armigera* as affecting approximately 180 host plants, reflecting its remarkable adaptability and broad host range. The pest attacks several economically important crops, including chickpea, pigeonpea, cotton, tomato, soybean, maize, sunflower, okra and marigold. Its larvae preferentially feed on reproductive plant parts, resulting in direct damage to marketable produce. The combination of high reproductive potential, multiple generations, wide host range and insecticide resistance makes management particularly challenging. Integrated Pest Management (IPM) is therefore essential for sustainable management. According to the definition presented in the seminar, IPM involves careful consideration and integration of available pest management techniques to discourage pest development, while keeping pesticide use at economically justified levels and minimizing risks to human health and the environment.

Taxonomy and Identification

Scientific name: *Helicoverpa armigera* (Hübner)

Order: Lepidoptera

Family: Noctuidae

Genus: *Helicoverpa*

Species: *armigera*

The adult is a stout-bodied nocturnal moth. Larvae are highly variable in colour and may appear green, yellowish, brown or reddish depending on developmental stage and food source. Larvae possess characteristic longitudinal stripes and prominent setae. Identification of the larval stage is particularly important because it is responsible for the majority of crop damage.

Biology and Life Cycle

Egg

Female moths lay eggs singly on leaves, flowers, buds and other suitable plant surfaces. A female may lay approximately 1,000–1,500 eggs under favourable conditions. Newly laid eggs are generally yellowish to yellow-white.

Larva

The larval stage is the principal damaging stage. Larvae pass through five instars. Early instars generally feed on leaves and tender plant tissues, while later instars preferentially attack flowers, fruits, pods and other reproductive structures.

Pupa

Pupation takes place in the soil. The pupal stage therefore provides an opportunity for management through appropriate cultural and soil-management practices.

Adult

Adults are nocturnal moths. After emergence, females mate and begin oviposition. The ability of adults to disperse among different crops contributes to the persistence and spread of infestations.

Under suitable environmental conditions, the complete life cycle may be completed in approximately 35–60 days.

Nature of Damage

H. armigera causes damage primarily through larval feeding. Young larvae may scrape leaf surfaces, whereas older larvae bore into reproductive structures. The characteristic damage includes:

Feeding on flower buds and flowers

Boring into fruits and pods

Damage to cotton bolls

Feeding on developing seeds

Formation of holes in fruits and pods

Contamination of produce with larval excreta

Increased susceptibility of damaged tissues to secondary infections

A single larva can damage several fruits or pods during its development. Feeding injuries may also provide entry points for secondary pathogens, further reducing crop quality.

Host Range, Distribution and Economic Importance

The pest has a very wide host range and has been reported from approximately 180 plant species. Important host crops include chickpea, pigeonpea, cotton, tomato, soybean, maize, sunflower, okra and marigold.

The economic importance of *H. armigera* varies with crop, location, pest population and environmental conditions, 30–57% in pigeonpea, 20–90% in chickpea, approximately 32% yield loss in tomato, up to 50–100% in cotton, 20–40% in soybean, 21.7% in maize and 35–42% in marigold.

These losses demonstrate the importance of early monitoring and timely management interventions.

Need for Integrated Pest Management

Dependence on insecticides alone is not a sustainable strategy for *H. armigera* management. Several factors justify the adoption of IPM.

Insecticide resistance

Repeated and indiscriminate application of insecticides has contributed to the development of resistance in *H. armigera*. Resistance reduces the effectiveness of conventional insecticides and increases the frequency and cost of applications.

Environmental concerns

Broad-spectrum insecticides may adversely affect predators, parasitoids and other beneficial organisms. Their excessive use can disturb ecological balance and contribute to secondary pest outbreaks and environmental contamination.

High adaptability

The ability of *H. armigera* to survive on numerous crops allows it to persist throughout different cropping seasons and move between hosts.

Economic losses

Severe infestation can substantially reduce yield and quality, affecting farm profitability and food security.

Sustainable pest suppression

Combining cultural, mechanical, biological and chemical tactics provides a more sustainable approach than dependence on any single management method.

Components of IPM

A successful *H. armigera* IPM programme combines several compatible components. The relative importance of each component depends on crop, region, pest density, weather and available management resources.

Cultural Control

Cultural practices modify the crop environment and can reduce pest establishment or survival. Timely sowing can help avoid periods of high pest pressure, while crop rotation and sanitation can reduce the continuity of suitable hosts. Removal or management of infested residues can reduce carry-over populations. Waseem *et al.* (2017) reported that chickpea intercropped with marigold was effective against *H. armigera* with lowest percent pod damage (10 %). Mishra *et al.* (2023) observed that early sowing of chickpea recorded the lowest mean population of *H. armigera* eggs and larvae during 2019–20 (eggs: 0.67; larvae: 2.65) and 2020–21 (eggs: 0.70; larvae: 0.89). Patel *et al.* (2024) noted that the minimum larval population (0.95) and fruit damage (no. basis: 20.81, wt. basis: 20.74) caused by *H. armigera* in okra were recorded on genotype Red One Long and it was at par with AOL 20-03.

Mechanical and Physical Control

Mechanical management includes hand collection of eggs or young larvae, removal of heavily infested plant parts and destruction of pest-infested residues. These practices are especially useful during early infestation when pest numbers are low. Pheromone traps are important tools for monitoring adult activity and can also contribute to mass trapping. Patel *et al.* (2024) evaluated different trap heights in pigeonpea and reported maximum male moth catches when traps were positioned 1.5 ft above plant height. The study illustrates the importance of proper trap placement when pheromone traps are used for monitoring or mass trapping.

Biological Control

Biological control includes conservation, augmentation and introduction of natural enemies. Predators such as lacewings, ladybird beetles, predatory bugs and spiders can contribute to natural suppression, while parasitoids attack specific developmental stages of the pest. Conservation of these organisms is especially important because indiscriminate broad-spectrum insecticide use can reduce their populations. Damasia *et al.* (2025) studied larval parasitization of *H. armigera* by a tachinid fly at Navsari over 2020–21 to 2022–23 and documented natural parasitization in the field. The study supports conservation of naturally occurring parasitoids as a component of biological control.

Microbial Control

Microbial pesticides provide important alternatives to conventional insecticides. HaNPV is widely used against *H. armigera* larvae and acts after ingestion, causing disease and eventual mortality. *Bacillus thuringiensis* produces insecticidal proteins that act primarily after ingestion by susceptible larvae. Entomopathogenic fungi such as *Beauveria bassiana* and *Metarhizium anisopliae* infect insects through the cuticle and can provide additional suppression. Entomopathogenic nematodes have also been evaluated against *H. armigera*. Kamaliya *et al.* (2019) studied that *Heterorhabditis indica* caused cent per cent larval mortality of 3rd, 4th and 5th instar larvae of *H. armigera* at inoculum levels of 20, 40, 60, 80 and 100 IJs/larva after exposure time of 120 hrs. Third instar larvae were most susceptible to *H. indica* than fourth and fifth instar larva. Purabiya *et al.* (2024) recorded that *B. thuringiensis* was most effective in the management of *H. armigera* with the minimum mean number of larvae per plant (0.93) on chickpea.

Botanical Control

Botanical insecticides can suppress *H. armigera* through toxic, antifeedant, repellent or growth-disrupting effects. Neem-based products are particularly important in IPM. Materials evaluated in the review include neem seed kernel extract, neem oil and azadirachtin, along with karanj and other plant extracts.

Chemical Control

Chemical insecticides remain an important component of IPM when pest populations exceed economically justified levels. Chemical intervention should be based on monitoring and threshold-based decisions. Correct dosage, spray timing, adequate coverage and rotation among effective modes of action are essential. Repeated use of the same mode of action can accelerate resistance development. Makani *et al.* (2025) observed that chlorantraniliprole 10 + lambda-cyhalothrin 5 ZC at 0.006% on soyabean recorded the lowest (1.01) larvae/plant, which was at par with novaluron 5.25 + emamectin benzoate 0.9 SC at 0.009% (1.11 larvae/plant) and novaluron 5.25 + indoxacarb 4.5 SC at 0.016% (1.21 larvae/plant) against *H. armigera*. Prajapati and Patel (2025) reported that lowest larval population of *H. armigera* on tomato in treatment chlorantraniliprole 18.5% SC (0.31) and it was at par with emamectin benzoate 5% SG (0.35).

Integrated IPM Modules

Field studies demonstrate the value of combining several management tactics. Choudhary *et al.* (2021) evaluated eight IPM module against *H. armigera* and found that module 7 showed least percent fruit damage and minimum number of larvae per plant on tomato. Khokhar and Rolania (2022) reported that minimum number of larvae of *H. armigera* per plant on tomato was observed on module 1, module 4 and module 5. Amogha *et al.* (2023) found that module 2 (Spinosad 45 SC + Datura leaf extract 25%) and module 3 (*Beauveria bassiana* + emamectin benzoate 5 SG) were most effective module against *H. armigera* on chickpea.

Future Prospects

Future IPM programmes should strengthen early-warning systems, area-wide monitoring and conservation biological control. Automated pheromone trapping, digital scouting and decision-support tools may improve the precision of pest detection and intervention. Resistance surveillance should be integrated into crop-protection programmes so that insecticide choices are informed by local susceptibility patterns.

Conclusion

Helicoverpa armigera remains a major pest because of its broad host range, high reproductive capacity, damaging larval behaviour, dispersal ability and capacity to develop resistance to insecticides. Sustainable management therefore requires integration of prevention, monitoring, threshold-based decision making and multiple compatible tactics. Cultural practices, trap crops, mechanical measures and pheromone monitoring can reduce pest establishment and improve early detection. Predators, parasitoids, HaNPV, *B. thuringiensis*, *B. bassiana*, *M.*

anisopliae and botanicals provide important non-chemical options. Selective insecticides remain useful when pest populations exceed economic thresholds, but they should be used judiciously and within a resistance-management programme. An integrated, ecologically based approach can improve pest suppression while conserving natural enemies and reducing unnecessary pesticide use.

Major IPM Practices for *H. armigera*

- Monitoring: field scouting, egg and larval counts, pheromone traps and crop-stage observations.
- Cultural: timely sowing, crop rotation, sanitation, trap crops and border crops.
- Mechanical/physical: hand collection, removal of infested plant parts and mass trapping.
- Biological: conservation and augmentation of parasitoids and predators.
- Microbial: HaNPV, *Bacillus thuringiensis*, *Beauveria bassiana*, *Metarhizium anisopliae* and entomopathogenic nematodes.
- Botanical: neem seed kernel extract, neem oil, azadirachtin and selected plant-derived products.
- Chemical: selective, threshold-based application with appropriate mode-of-action rotation.

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