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Helicoverpa—The Global Problem

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The legume pod borer or cotton bollworm [*Helicoverpa armigera* (Hübner)] is one of the most important constraint to crop production globally. It is polyphagous and attacks more than 182 plant species, including cotton (Plate 1.1a), chickpea (Plate 1.1b), pigeonpea (Plate 1.1c), peas, cowpea, sunflower, sorghum, groundnut, field beans, tomato (Plate 1.1d), tobacco, maize and a range of vegetables, fruit crops and tree species. *Helicoverpa armigera* is widely distributed in Asia, Africa, Australia and the Mediterranean Europe.

Extent of losses

Crop production in many countries, especially in the semi-arid tropics (SAT), is severely threatened by the increasing difficulty in controlling insect pests such as *H. armigera*. This pod borer has developed a high level of resistance to many of the commonly used insecticides (Kranthi et al. 2002). *Helicoverpa* causes an estimated loss of US$927 million in chickpea and pigeonpea, and possibly over US$5 billion on different crops worldwide (Sharma 2001). A conservative estimate is that over US$1 billion is spent on insecticides to control this pest. Therefore, in addition to the huge economic losses caused directly by this pest, there are several indirect costs accruing from the deleterious effects of pesticides on the environment, as also human and animal health.

The problem

Intensification of agriculture on a global level is the root cause for the enhanced damage caused by many pests. Farmers around the world use chemical

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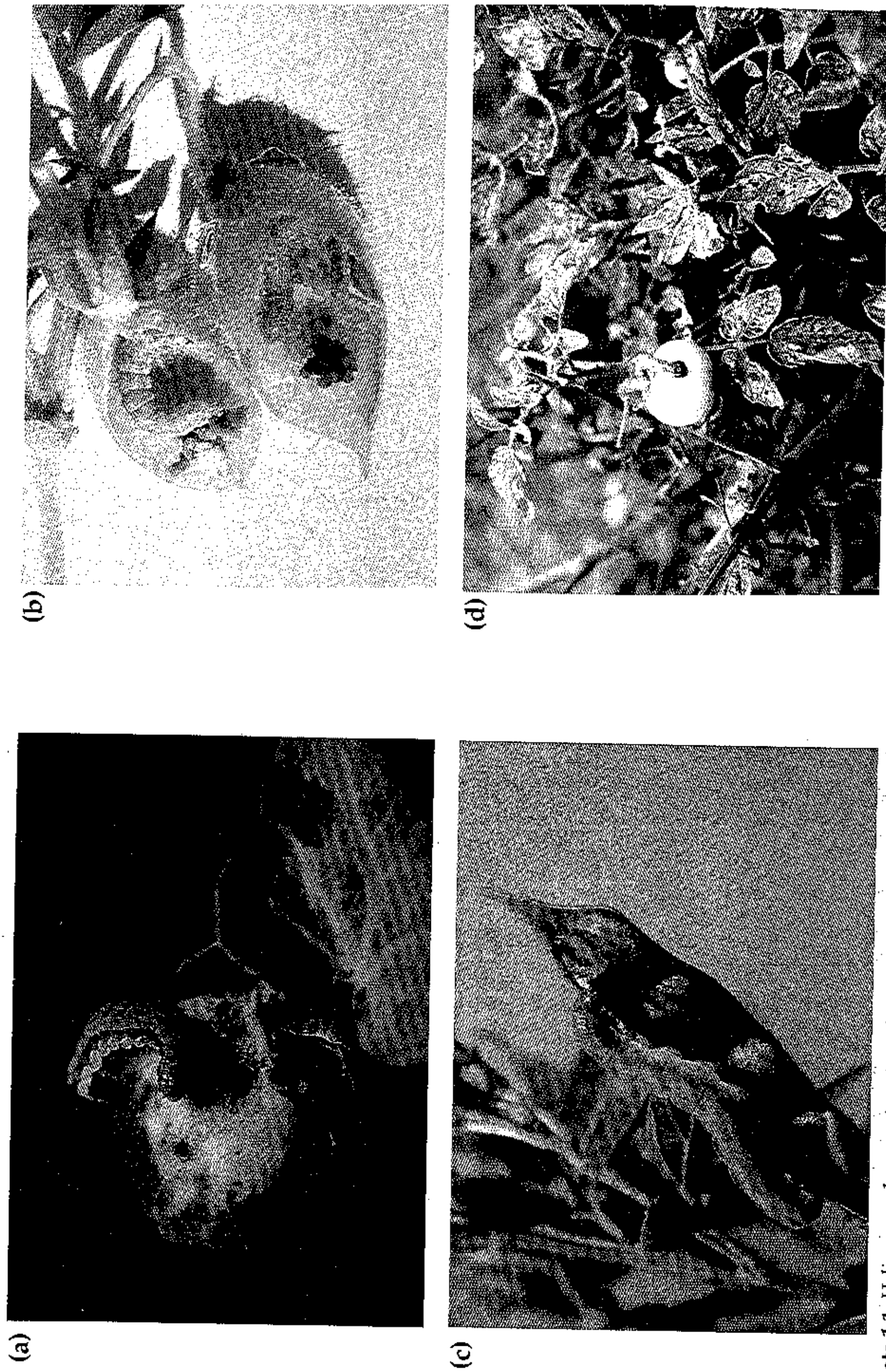

(a) (b) (c) (d)

Plate 1.1: *Helicoverpa* damage in cotton (a); chickpea (b); pigeonpea (c) and tomato (d).

pesticides indiscriminately to control *Helicoverpa*. Pesticide manufacturers have produced more potent and toxic pesticides whenever *Helicoverpa* developed resistance to the prevailing insecticides. This vicious cycle has led to a stage where *Helicoverpa* has developed resistance to most of the available pesticides, especially to synthetic pyrethroids. It has, therefore, become necessary to devise a suite of pest management tactics to contain this pest. Environmentally safe technologies are not yet ready in a form to be delivered to farmers, although the use of integrated pest management (IPM) strategies can reduce the negative environmental effects of the existing chemical pesticides (Sharma 2001).

Components of *Helicoverpa* management

The major pest status of *Helicoverpa* is because of its high mobility, polyphagous nature, high reproductive rate and ability to undergo diapause. All of these traits make it well adapted to exploit the transient habitats created by intensification of agriculture. Management strategies for *Helicoverpa* require different control tactics based on the relationship between population density and economic loss. However, some thumb rules can be used generally. Pest management strategies for *Helicoverpa* include cultural management of the crop and its environment; biological control using predators, parasites and microbial pesticides; sex pheromones for population monitoring or mating disruptions; host plant resistance; and chemical control.

Economic threshold levels

Field monitoring and determining the economic threshold levels (ETLs) for different crops and cropping systems is essential for a rational pest management effort, especially in case of chemical pesticide application. Since the ETLs will vary with genotypes, it is essential to determine these for the newly developed cultivars with varying levels of resistance to *Helicoverpa*. Similarly, we need to assess the contribution of pest-resistant cultivars and natural enemies in IPM for sustainable crop production.

Management options

Management options include cultural manipulation of crops such as the time of sowing, cropping season spacing and fertilizer application to minimize pest damage. Deep plowing, interculture operations and flooding reduce the survival and build of *Helicoverpa*. Intercropping or strip cropping with marigold, sesame, soybean, mung bean, cowpea and sunflower can minimize damage to the main crops. Strip cropping also increases the efficiency of chemical control. Hand picking of large-sized larvae from crops or shaking of plants (such as pigeonpea) to dislodge and destroy the larvae can also reduce *Helicoverpa* damage to some extent.

Host plant resistance

Host plant resistance is one of the cheapest and most effective management tools for reducing damage by *Helicoverpa*. Development of improved crop varieties with resistance or tolerance to *Helicoverpa* is highly useful for subsistence farming in developing countries (Sharma et al. 1999). Although crop improvement research to develop resistant cultivars has been ongoing for the last two decades, the progress is very limited. This is mainly due to the low level of resistance available in the cultivated species. However, some of the germplasm lines possess stable and heritable resistance traits (low level) that can be exploited to breed lines with greater levels of resistance to *Helicoverpa*.

High levels of resistance are available in the wild species of some crops. For example, wild relatives of pigeonpea such as *Cajanus scarabaeoides, C. sericeus* and *C. acutifolius* can be used as sources of resistance to *Helicoverpa*. Some of the wild species do not cross with cultivated species, and will need embryo rescue using tissue culture techniques for wide hybridization.

Genetic engineering (or genetic transformation) techniques have enabled the transfer of genes [toxin genes from *Bacillus thuringiensis* (*Bt*), trypsin inhibitor or lectins] from other organisms. Several studies with transformed plants have shown that the technique offers considerable promise. Genetically transformed crop cultivars have been grown on a large scale in Brazil, China, Canada and the USA. However, there are certain concerns in some countries, and these need to be addressed by scientists before the genetically transformed plants are accepted globally. For long-term effectiveness of host plant resistance, it is essential to deploy a combination of strategies:

- Identify lines with diverse resistance mechanisms and pyramid resistance genes into the adapted genotypes.
- Tap resistance genes from the wild relatives.
- Combine HPR with novel genes (*Bt*, SBTI and lectins) in order to make plant resistance a viable option in pest management.
- Deploy more than one gene in transgenics to increase the levels and durability of resistance.

Biological control

Biological control involves deploying the natural enemies (both parasites and predators) to control insect pests. Substantial efforts have been made to augment existing populations or introduce exotic natural enemies (parasitoids and predators) in order to achieve satisfactory levels of control. Since there is the need to produce large numbers of parasitoids or predators economically, emphasis has been placed on *Trichogramma* species that are amenable to mass rearing. Despite moderate success in some areas, the results have not been encouraging so far. Encouraging natural predators such as birds by providing bird perches is quite effective, but not consistent, as we do not have control on the migratory nature of birds.

Biopesticides are an emerging area of promise. In addition to *H. armigera* Nucleopolyhedrosis Virus (HaNPV), some strains of *Pseudomonas* spp. and entomopathogenic fungi [*Beauveria bassiana* (Balsamo) and *Metarrhizium anisopliae* (Metsch.)] are effective in controlling *Helicoverpa*. Natural plant products such as neem (1% oil emulsion or 5% kernel extract), custard apple seed extract and karanj *(Pongamia)* oil can also be used for *Helicoverpa* control under low to moderate levels of infestation.

Chemical control

Use of chemical pesticides still remains the most effective practice to manage *Helicoverpa*, especially for high value crops such as cotton and vegetables. As indicated earlier, indiscriminate and excessive use of chemical pesticides has resulted in the development of insecticide resistance and resurgence of pest populations. This 'insecticide treadmill' is exasperated by the use of poor application equipment, unreliable products in the market and poor choice of insecticides. This has further led to severe pest epidemics and many farmers have committed suicide as they were unable to repay the loans taken for managing *Helicoverpa*. Therefore, cautious decisions have to be made on the choice, dose and method of application based on ETLs. It is always preferable to alternate pesticides with different modes of action so that insects do not develop resistance.

Integrated approach

Considering the complexity of managing *Helicoverpa* effectively, it is imperative that we follow an integrated approach. This integration will involve agronomic and cultural management, host plant resistance, biological control, natural pesticides and judicious use of chemical pesticides. A thorough analysis of multi-trophic interactions in the context of benefits versus crop damage and yield loss will help in deciding management options. At the same time, we should explore the possibilities of maximizing the efficacy of insecticide use while minimizing the harmful effects on the environment. Using long-term climatic and insect population data, it is now possible to predict the chances for pest build up in the crop. Although the current models do not predict the pest occurrences properly, there is good scope to use the emerging 'Information and Communication Technologies (ICT) to accurately predict pest build up. This can then be used as an early warning system to advice farmers appropriate management practices to minimize damage by *Helicoverpa*.

Considerable research has been carried on *H. armigera* at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). We would like to share some research results and learn from other scientists' research so that we can plan an appropriate research and development pathway to manage *Helicoverpa*.

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