

# **HELICOVERPA ARMIGERA RESISTANCE TO INSECTICIDES IN PAKISTAN**

**Mushtaq Ahmad, M. I. Arif, Zahoor Ahmad  
and M. R. Attique  
Central Cotton Research Institute  
Multan, Pakistan**

## **Abstract**

A regular monitoring of insecticide resistance in *Helicoverpa armigera* (Hübner) collected from different areas of Pakistan was conducted from 1991 through 1997 using an IRAC leaf-dip method. Generally, a moderate resistance was found to cypermethrin during 1991 to 1993; but it reached to very high levels during 1994 to 1997, following an outbreak of *H. armigera* on cotton in 1994 when frequent applications of various insecticides were made. Endosulfan resistance was low from 1991 to 1993 and it also became high from 1994 to 1997. Resistance to profenofos and chlorpyrifos remained very low to low levels up to 1995, but rose to moderate levels in 1996 and 1997. However, resistance to thiodicarb was consistently very low throughout the seven-year period. Unless a management strategy is adopted, insecticide resistance in *H. armigera* and other pests may continue to threaten cotton production in Pakistan.

## **Introduction**

The cotton bollworm, *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) has emerged as the most destructive pest of cotton in Pakistan during nineties. One of the major contributing factors to its unabated attacks on cotton is the development of insecticide resistance in this pest in Pakistan (Ahmad et al., 1995, 1997). During 1997 it played a havoc with our cotton and it remained largely uncontrolled.

A regular resistance monitoring program for *H. armigera* was initiated in 1991 in Pakistan. Our bioassay studies from 1991 through 1993 demonstrated that resistance was moderate to high to cypermethrin (pyrethroid), moderate to endosulfan (organochlorine) and low to profenofos, chlorpyrifos (organophosphates) and thiodicarb (carbamate); and that the latter three compounds were still effective against *H. armigera* in the field (Ahmad et al., 1995). Since then, resistance monitoring of these insecticides has been continued in the local populations of *H. armigera* and the results are presented herein.

## **Materials and Methods**

### **Insects**

Fifth or sixth instars of *H. armigera* were collected from various locations in Pakistan during 1991 to 1997. Each collection was made from a 5-acre block of a particular host crop. The larvae were fed in the laboratory on a semi-synthetic diet (modified from Ahmad and McCaffery 1991), which consisted of chickpea flour (300g), ascorbic acid (4.7g), methyl-4-hydroxybenzoate (3g), sorbic acid (1.5g), streptomycin (1.5g), corn oil (12ml), yeast (48g), agar (17.3g) and distilled water (1300ml) with a vitamin mixture. Adults were fed on a sucrose solution with the addition of vitamins and methyl-4-hydroxybenzoate.

### **Insecticides**

Commercial formulations of cypermethrin (Arrivo, 100 g/l EC [emulsifiable concentrate]; FMC, Philadelphia, USA), endosulfan (Thiodan, 350 g/l EC; AgrEvo, Berlin, Germany), profenofos (Curacron, 500 g/l EC; Novartis, Basle, Switzerland), chlorpyrifos (400 g/l EC; DowElanco, Indianapolis, USA), and thiodicarb (Larvin, 80% DF [dry flowable]; Rhone-Poulenc, Lyon, France) were obtained from the respective manufacturers.

### **Bioassays**

Newly molted second instars from the F<sub>1</sub> laboratory generations were exposed to different insecticides using the leaf dip technique as recommended by the Insecticide Resistance Action Committee (IRAC) of GIFAP (Anonymous, 1990). Cotton leaf discs (5 cm diameter) were cut and dipped into the test solutions for 10 seconds with gentle agitation, then allowed to dry on paper towel. Five larvae were released on to each leaf disc placed in 5-cm-diameter petri dishes. Eight batches of five larvae were used for each treatment and 5 to 11 serial concentrations were used for each test insecticide. The same number of leaf discs per treatment was dipped into distilled water to serve as untreated checks. Moistened filter papers were placed beneath the leaf discs to avoid desiccation of leaves in the test containers. Serial dilutions of the test compounds were prepared using distilled water as ppm of the active ingredient. After releasing the larvae, test containers were covered with a piece of black cloth to minimize cannibalism. Before and after the treatment, larvae were kept in the laboratory at a constant temperature of 25±2°C with a photoperiod of 14 h.

### **Data Analysis**

Larval mortalities were assessed after 48 h. Larvae were considered dead if they failed to respond to stimulation by touch. Percent mortalities were corrected for untreated (check) mortalities using Abbott's (1925) formula. To calculate LC<sub>50</sub>s, data were analyzed using a computer program (probit analysis) (Finney, 1971). Resistance factors (RFs) were determined by dividing the LC<sub>50</sub> of each insecticide for the field strain by the corresponding LC<sub>50</sub> for the susceptible Reading (UK) strain. The year-wise averages

of the RFs for the populations tested in a single year (usually 2 to 5 populations) are presented in Fig. 1.

## **Results and Discussion**

### **Cypermethrin**

Cypermethrin has been the most commonly used pyrethroid in Pakistan for the last 15 years. Our data showed that resistance was the highest to this pyrethroid in *H. armigera* (30- to 223-fold) (Fig. 1a). Initially, RFs to cypermethrin remained similar from 1991 to 1993 (30-44). In 1994, there was a heavy infestation of *H. armigera* on cotton and the farmers applied frequent applications of insecticides, particularly the pyrethroids. Consequently, resistance rose to the highest levels during 1994 to 1996 (118-223 fold). In 1997 there was again a severe attack of *H. armigera* on cotton. But this time, the farmers mostly used non-pyrethroids, as the pyrethroids were no longer effective and were not recommended by the agriculture department. As a result, cypermethrin resistance was recorded much lower in 1997 (97-fold) than in years 1995 and 1996.

### **Endosulfan**

There was a low resistance (18-20 fold) to endosulfan from 1991 to 1993 (Fig. 1b). After the 1994 outbreak of *H. armigera*, endosulfan resistance climbed to high levels (51- to 87-fold). However, except for 1995, RFs for endosulfan remained similar from 1994 to 1997 (42-51). Due to its field failures from 1994 onwards, endosulfan is no longer being targeted for *Helicoverpa* control in Pakistan. It is now applied for whitefly control, especially in mixtures with pyrethroids. Nevertheless, *H. armigera* does get exposure to endosulfan when it infests cotton in concurrence with whitefly.

### **Profenofos and Chlorpyrifos**

Resistance to profenofos remained low in *H. armigera* from 1991 to 1995 (2- to 13-fold) (Fig. 1c). It rose to 21-fold and 26-fold in 1996 and 1997 respectively. Profenofos has been used extensively on cotton in Pakistan for the last 15 years, mostly as a mixture with cypermethrin. It appears that the development of profenofos resistance has particularly been slow in *H. armigera*. For the last couple of years it is being applied alone for the control of *Helicoverpa*, because of the ineffectiveness of profenofos/pyrethroid mixtures for controlling this pest due to high pyrethroid resistance. Recently, its intensive use has probably accelerated the selection of resistant genotypes, which were already present in the local populations of *H. armigera*.

Tolerance to chlorpyrifos in *H. armigera* has been very low (<3.5-fold) from 1992 to 1995 (Fig. 1d), even lower than profenofos. Chlorpyrifos resistance rose sharply to 24-fold and 32-fold in 1996 and 1997 respectively. For the last couple of years this insecticide has also been used extensively for the control of *Helicoverpa* in Pakistan and consequently, the selection pressure was enhanced considerably which led to increase in its resistance level.

It is quite worrying that we are fast losing susceptibility to organophosphates (OPs) in the Pakistani populations of *H. armigera*. Consistent with our laboratory bioassays, we have received many reports of control failures of profenofos and chlorpyrifos against *H. armigera* on cotton during 1996 and 1997. The failure of pyrethroids and endosulfan to give an acceptable control of *H. armigera* due to resistance development has prompted the use of OPs particularly profenofos and chlorpyrifos which has manifested into greater resistance to these insecticides recently as evinced in the present study. So a great care must be taken to preserve OP susceptibility by avoiding their overuse.

### **Thiodicarb**

Amazingly, there has been very low tolerance to thiodicarb (2- to 8-fold) in *H. armigera* from 1991 to 1997 (Fig. 1e), in spite of its increasing usage recently. This indicates that there may not be a cross resistance between the OPs and thiodicarb that is very encouraging for the management of insecticide resistance in *H. armigera*. No reports of control failure of thiodicarb have so far been received from the field and it remains fully effective if applied correctly, at the right time and dose. Thiodicarb may continue to be a good tool for the control of *H. armigera* if it is not overused and its use is limited to preferably one spray or at the most two sprays per cotton season.

### **Resistance Management**

Since 1992, we have been advocating a resistance management strategy for *H. armigera* and other pests of cotton, based on the rotation of effective insecticides belonging to different classes. Although the individual progressive farmers did follow our recommendations and got better yields, yet the strategy could not be implemented area-wide, because of hundreds of thousands of illiterate small farmers and hundreds of pesticide distributors with their own commercial interests. Consequently, as our results show, resistance problem has been aggravating leading to frequent outbreaks of *H. armigera* or whitefly (*Bemisia tabaci*) with serious control problems, which resulted into a persistent decline in yield of Pakistani cotton since 1992. The whitefly has also developed a high resistance to conventional insecticides in Pakistan (Ahmad, 1996). With only a few effective insecticides left, our hopes are now with the introduction of new chemistries that are in sight for *H. armigera* and whitefly. But until a resistance management strategy of a rotation of all the available chemistries along with other tactics of integrated pest management is adopted, the new compounds may also be misused and fall prey to the pre-existent or new mechanisms of resistance, which are presently found at low frequencies in the insect populations of Pakistan.

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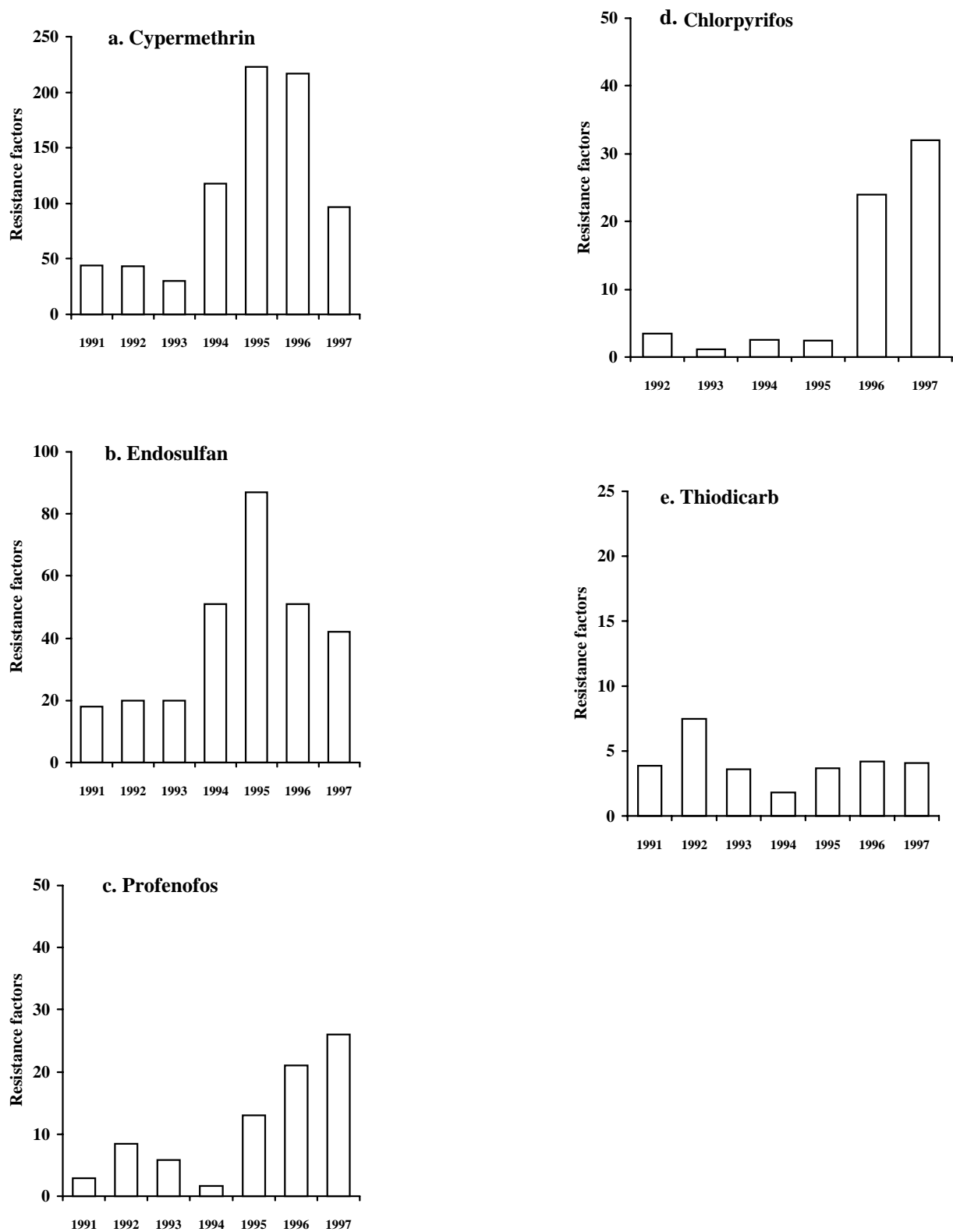


Figure 1. Resistance factors of *Helicoverpa armigera* to a) cypermethrin, b) endosulfan, c) profenofos, d) chlorpyrifos, e) thiodicarb.