Insecticide resistance profile from 1991-2002 for *Helicoverpa armigera* in Pakistan

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ABSTRACT

Cotton acts as the mainstay in Pakistan's economy. Indiscriminate and excessive use of chemical pesticides applied on this crop created resistance in Helicoverpa armigera *and other insect pests making their control difficult. An insecticide resistance monitoring program therefore, was started in 1991 at the Central Cotton Research Institute, Multan to formulate effective pest management strategies. Over the last twelve years development of moderate to very high resistance was observed in* H. armigera *for endosulfan (RF currently around 40) and pyrethroids such as cypermethrin and deltamethrin with RFs of several hundred. Among organophosphates, resistance was very low for profenofos (RF currently 5 to 15) but moderate to very high for monocrotophos (current RF of c. 30). Resistance to the carbamates, thiodicarb (RF <5) and methomyl (RF <11) was negligible to very low. For new chemistry compounds like spinosad, the resistance was extremely low, whereas, some resistance occurred against indoxacarb. As a consequence of these findings, the Central Cotton Research Institute has recommended changes in the insecticide use strategy over the years. The subsequent changes in the pattern of insecticide use by cotton farmers have resulted in considerable reductions in the monitored levels of resistance to a number of chemicals in Pakistan.*

Introduction

In Pakistan, *Helicoverpa armigera* (Hübner) attained the status of an important pest during the 1990s. Because of extensive and indiscriminate use of pesticides on cotton and vegetables, it exhibited resistance to all the commonly used insecticide groups (Ahmad *et al*., 1995, 1997, 1999, 2001, 2003) and thus led to serious control problems during its outbreaks.

A regular monitoring program to develop effective pest management strategies for *H. armigera* was started in 1991 at Central Cotton Research Institute, Multan, Pakistan. Our resistance monitoring results obtained during the last twelve years (1991-2002) for some insecticides are presented in this paper.

Materials and Methods

Insects

About full-grown larvae of *H. armigera* were collected from various localities in Pakistan. Each collection was made from a 5-acre block of each host. The larvae were fed in the laboratory on a semi-synthetic diet (modified from Ahmad and McCaffery, 1991), consisting of chickpea flour (300 g), ascorbic acid (4.7g), methyl-4-hydroxybenzoate (3 g), sorbic acid (1.5 g), streptomycin (1.5 g), corn oil (12 ml), yeast (48 g), agar (17.3 g) and distilled water (1300 ml) with a vitamin mixture. Adults were fed on a solution containing sucrose (50 g), vitamin mixture (10 ml), methyl-4-hydroxybenzoate, (1 g) and distilled water (500 ml).

Insecticides

Commercial formulations of endosulfan (Thiodon, 35 % EC, AgrEvo), cypermethrin (Arrivo, 10% EC, FMC), deltamethrin (Decis, 2.5% EC, AgrEvo), profenofos (Curacron, 50% EC, Novartis), monocrotophos, (Nuvacron, 40% SCW, Novartis), thiodicarb (Larvin, 80% DF, Rhone-Poulenc), methomyl (Lannate, 40% SP, DuPont), indoxacarb (Steward, 15% SC, DuPont), spinosad (Tracer, 48% SC, Aventis) were used for bioassays.

Bioassay

Newly moulted second instar larvae from F_1 laboratory generations were exposed to different insecticides using the leaf-dip technique as recommended by Insecticide Resistance Action Committee (IRAC) (Anonymous, 1990). Serial dilutions of the test compounds were prepared using distilled water. Cotton leaf discs (5 cm diameter) were cut and dipped into the test solution for 10 seconds with gentle agitation, then allowed to dry on paper towel. Five larvae were released onto each leaf disc placed in a 5-cm diameter Petri dish. Eight replications of five larvae were used for each concentration and 7-10 serial concentration were used for each test insecticide. The same number of leaf discs per treatment was dipped into distilled water as an untreated check. Moistened filter papers were placed beneath the leaf discs to avoid desiccation of leaves in the petri dish. After releasing the larvae, test containers were covered with black cloth to minimize cannibalism.

Data analysis

Larval mortalities were assessed after 48 h. Larvae were considered dead if they failed to respond to stimulation by touch. Results were expressed as percent mortalities, corrected for untreated (check) mortalities using Abbott's (1925) formula. To calculate LC_{50}, data were analysed using a computer probit analysis program (Finney, 1971). Resistance factors (RFs) were determined by dividing the LC_{50} of each insecticide for the field strain by the corresponding LC_{50} for the susceptible strain.

Results and Discussion

Cyclodiene (endosulfan)

Helicoverpa armigera resistance to endosulfan fluctuated from low to high levels during present studies. Resistance remained low from 1991 to 1994 (Ahmad *et al*., 1995), high from 1995 to 1998 (Ahmad *et al*., 1998) and again low to moderate during 1999 to 2002 (Figure 1a). Endosulfan is normally applied on cotton against whitefly (*Bemisia tabaci*), therefore, *H. armigera* gets an indirect exposure to this compound. After the introduction of new chemistries during 1997-1998, use of endosulfan was reduced against cotton whitefly, which seemed responsible for subsequent lowering of resistance in *H. armigera*.

Synthetic Pyrethroids (cypermethrin, deltamethrin)

Cypermethrin resistance in *H. armigera* was low to very high during the period reported. After a steady increase from 1991 to 1996 (Ahmad *et al*., 1997) resistance levels dropped considerably but rose again in 2001-2002 (Figure 1b). Resistance to deltamethrin ranged from low to high with the same pattern of resistance levels (Figure 1c). Increased resistance to both the compounds in last years of current studies seemed mainly due to the excessive use of pyrethroids against *Earias* spp. to combat their high incidence during the last three to four years.

Organophosphates (profenofos, monocrotophos)

Profenofos proved very effective against *H. armigera* as the resistance factors remained at low levels despite its increasing use during the reported years (Figure 1d). Resistance to monocrotophos was moderate to very high. Due to poor performance, use of monocrotophos on cotton was greatly reduced by the farmers, which resulted in a decrease in resistance during the last couple of years (Figure 1e).

Carbamates (thiodicarb, methomyl)

Overall, resistance to thiodicarb has been very low (Figure 1f) Ahmad *et al*., 2001). It seems to be a unique product among the conventional chemistries for being persistently very effective against *H. armigera*. Resistance to methomyl was moderate in 1993-1994, high during 1995-1996 (Ahmad *et al*., 2001) and low during the following years (Figure 1g). Carbamate resistance in Pakistan seemed not to be a result of cross resistance as resistance to other groups (mainly endosulfan and pyrethroids) has been generally increasing steadily.

New chemistries (indoxacarb, spinosad)

Generally, very low levels of resistance in *H. armigera* were found to indoxacarb (Figure 1h) and spinosad (Figure 1i). There seems no cross resistance between these chemistries and conventional groups of insecticides as both the new chemistries have so far performed well against this bollworm in Pakistan.

Our results of resistance monitoring have been followed by the agriculture departments of Punjab and Sindh provinces to make recommendations for chemical control of cotton pests. The pesticide industry has also made use of our laboratory results. The chemicals which had lost their efficacy became effective again after proper management in the pest control policy (Table 1).

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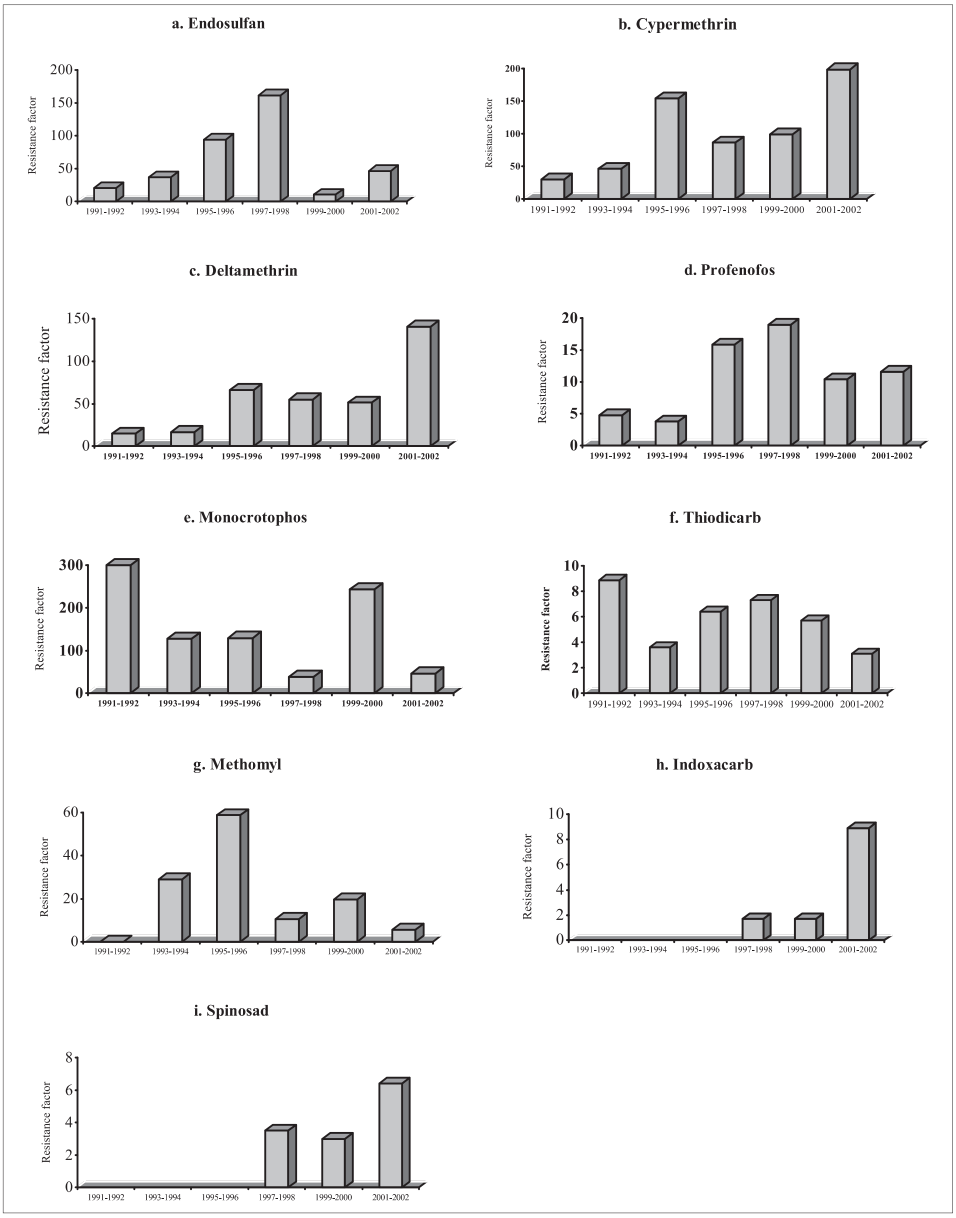

Figure 1. *Resistance factors of* Helicoverpa armigera *to a) endosulfan, b) cypermethrin, c) deltamethrin, d) profenofos, e) monocrotophos, f) thiodicarb, g) methomyl, h) indoxacarb and i) spinosad.*

Table 1. *Revival in efficacy of insecticides after their use was discontinued/reduced against* Helicoverpa armigera.

Insecticides	RF values while included in Agriculture department recommendations	RF values after taken out of Agriculture department recommendations
Endosulfan	1998 = 73 - 317 fold	2002 = 20 - 48 fold
Cypermethrin	1995 = 108 - 205 fold	2000 = 49 - 67 fold
Deltamethrin	1996 = 44 - 94 fold	2000 = 29 - 38 fold
Lambda-cyhalothrin	1999 = 284 - 500 fold	2001 = 64 - 339 fold
Chlorpyrifos	1998 = 31 - 35 fold	2002 = 3 - 11 fold