# PYRETHROID RESISTANCE IN THE POD BORER, *HELICOVERPA ARMIGERA*, IN SOUTHERN INDIA.

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## ABSTRACT

Changes in the $LD_{50}$ of *Helicoverpa armigera* to cypermethrin at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and in the coastal cotton-growing region of Andhra Pradesh State during the period 1986-92 are summarised and discussed. A provisional discriminating dose of 1ug cypermethrin was evaluated at ICRISAT and changes in resistance to cypermethrin monitored throughout 1991/92. Resistance was related to seasonal changes in insecticide use; it was lowest in August and increased with progression of the season. Prospects for insecticide resistance management of *H. armigera* in Andhra Pradesh are briefly discussed.

## INTRODUCTION

Synthetic pyrethroids were first used on cotton in S India in 1982 mainly against *Spodoptera litura* (F.) and *Earias* spp.; and were increasingly used against *Helicoverpa armigera* as it replaced these species. Pyrethroid resistance in *H armigera* was heralded in 1987 by widespread field control failures over much of the coastal cotton-growing belt of Andhra Pradesh (Dhingra *et al*, 1988; McCaffery *et al* 1989), and with a decline in average lint yields from over 430 to under 170 kg/ha (Anon, 1989 b and c). NRI, in collaboration with ICRISAT and Reading University, has been monitoring resistance in *H.armigera* since 1986. This paper summarises the techniques used, compares the data obtained in Andhra Pradesh, with particular reference to the 1991-92 season, and discusses future prospects for resistance management of *H.armigera* in southern India.

## METHOD AND MATERIALS

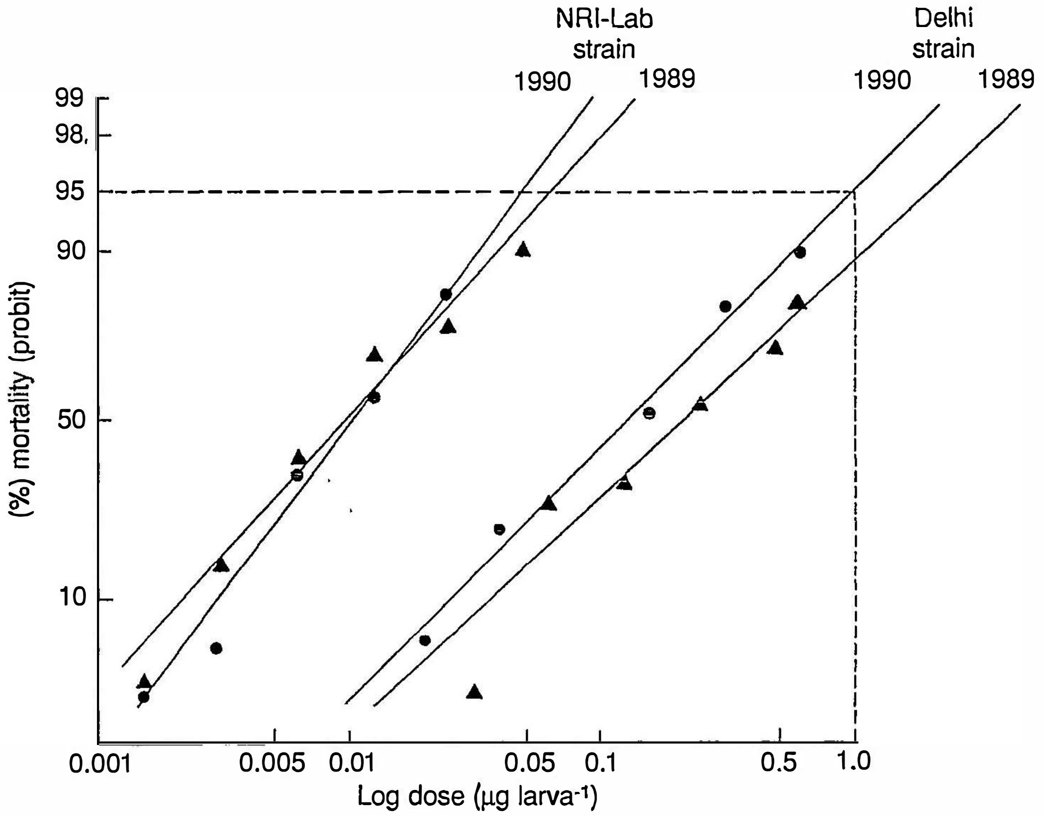
### Dose/response monitoring

From 1986 to 1991 bioassays were performed on the F1 of larvae field-collected from sorghum, pigeonpea, chickpea and cotton at ICRISAT and farms in Andhra Pradesh. Cypermethrin (cis:trans, 1:1) (ICI Agrochemicals Ltd) was applied topically to larvae in the weight range 30-50 mg, as described by Armes *et al* (1992).

Discriminating dose monitoring

Two strains were used to calibrate a cypermethrin discriminating dose for *H.armigera* larvae weighing 30-50 mg. The NRI strain, originally from Sudan, was wholly susceptible; the other, from the Indian Agricultural Research Institute (IARI), Delhi, was slightly tolerant (Figure 1). A provisional discriminating dose of 1ug/larva, which killed 95% of the Delhi strain larvae, was derived (Figure 1).

**FIGURE 1.** Response to cypermethrin of the 'NRI laboratory' and 'Delhi' strains of *H.armigera*.



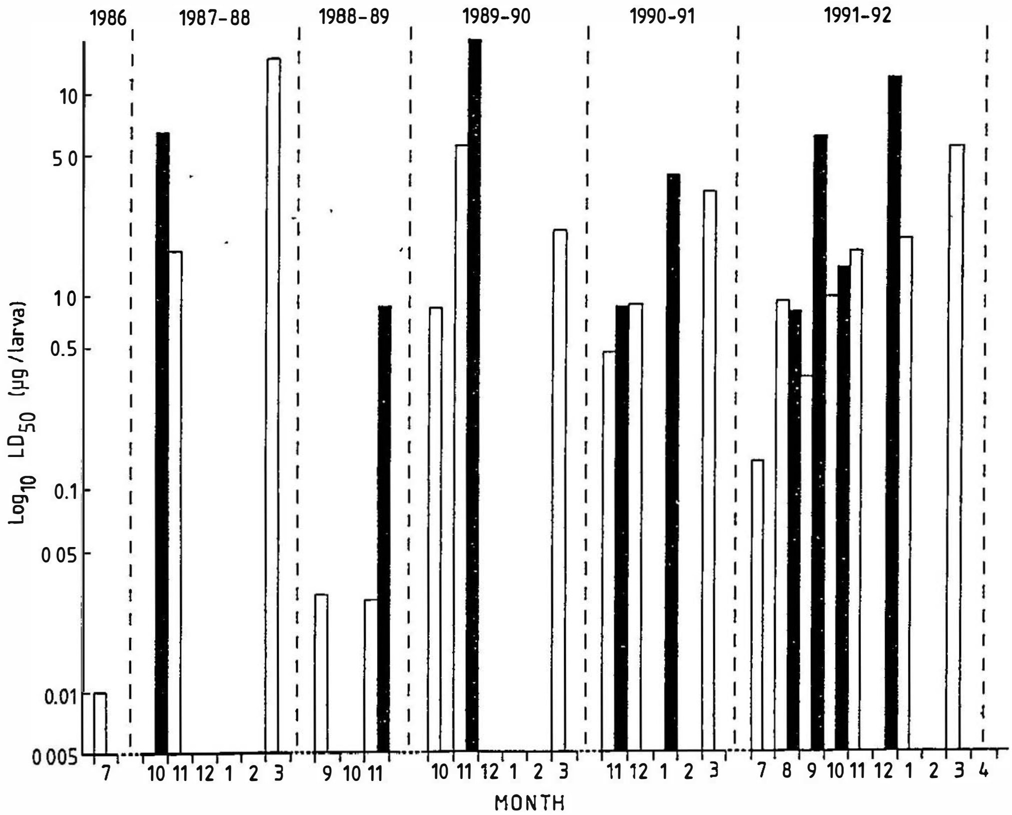

From June 1991 to April 1992, samples of 150-400 eggs and/or small larvae were taken from infested host plants every 1-2 weeks at ICRISAT, reared on diet to the 30-50 mg range and treated with the discriminating dose. Control larvae were treated with acetone alone. Larvae were held at 26$\pm$1$^{\circ}$C and mortality assessed after 72 hours.

RESULTS AND DISCUSSION

Dose/response monitoring

Between 1986 and 1992 pyrethroid resistance varied considerably between and within years and locations (Figure 2) In July 1986, there was no evidence of tolerance to cypermethrin at ICRISAT, but by October 1987, field failures were reported from cotton in eastern A.P. and control problems were experienced at ICRISAT (Figure 2). In general, resistance levels over the 5 seasons increased as each season progressed. This was particularly evident for the 1991/92 season for which there was continuous data.

**FIGURE 2.** Seasonal changes in cypermethrin resistance in *H.marmigera* from ICRISAT (unshaded) and Andhra Pradesh coastal cotton districts (shaded). Based on average monthly LD50 values; from McCaffery *et al.* (1989) and Armes *et al.* (1992).




In the cotton areas, increases in resistance could be attributed to local selection of resistant genotypes in response to applications of pyrethroids. However at ICRISAT, where pyrethroids were not extensively used, little local selection for resistance would have taken place. Seasonal increases in pyrethroid resistance at ICRISAT tended to reflect those recorded in the cotton areas in Eastern A.P., and may therefore have resulted from immigration of resistant moths into the Hyderabad area on the prevailing NE to E winds between October and December (Pedgley *et al.*, 1987; McCaffery *et al.*, 1989).

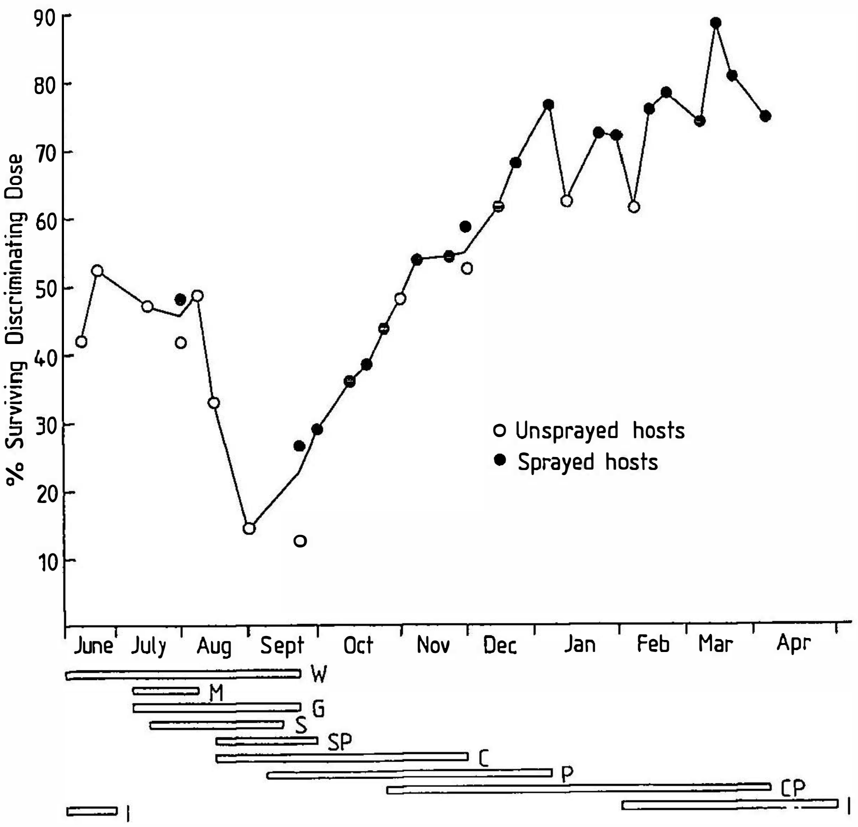
Discriminating dose monitoring

Ideally, monitoring should be able to detect resistant individuals at a phenotypic frequency close to 1%, a level not attainable with dosage/response assays (Roush and Miller, 1986). Moreover, the large numbers of insects required, inevitable time lag, and dubious accuracy of assays performed on the F1, are not compatible with a reactive IRM strategy.

Although a discriminating dose of 1ul was effective, the Delhi strain, on which it was based, was significantly more tolerant, and had a lower log-dose-probit (ldp) slope, than the NRI (Sudan) susceptible strain.

It has not been possible to isolate a homogenous, pyrethroid susceptible field strain in India, and, as a discriminating dose based on the NRI strain would overestimate pyrethroid resistance in Indian *H.armigera*, the Delhi strain was used as the standard. However, because of its low slope with cypermethrin, the ldp line of the Delhi strain significantly overlapped those of resistant field populations from southern India (Armes *et al.*, 1992). It was not therefore possible to accurately determine the frequency of resistance on the basis of a discriminating dose calibrated for this strain.

**FIGURE 3.** Changes in cypermethrin resistance in *H.armigera* at ICRISAT during 1991/92, based on percent larvae surviving a lug discriminating dose. Bars indicate periods of host-plant susceptibility to *H.armigera* at ICRISAT (W = weeds; M = mung bean; G = groundnut; SP = short duration pigeonpea; L = medium & long duration pigeonpea; C = cotton; CP = chickpea; I - irrigated vegetables).




At ICRISAT, resistance in the first *H.armigera* generation of the kharif (rainy) season in late June-late July 1991 was high, probably as a result of insecticide use during the March-May summer period on irrigated vegetables (Figure 3). Its subsequent decline could have resulted from early-season build up on unsprayed crops and weed hosts, and dilution by susceptible populations. However, by late October resistance had re-attained the early kharif level of about 45%. This increase was closely synchronised with the appearance of the first generation of moths from early planted cotton, which would have received 2-3 applications of insecticides. Resistance continued to increase until February, as an overlapping succession of host crops were available (sorghum, pigeonpea, chickpea, groundnut), with the legumes receiving 1-6 sprays against *H.armigera*. Resistance remained high up to the end of the cropping season in early April (Figure 3).

## Prospects for Insecticide Resistance Management in Andhra Pradesh

For a resistance management strategy to be successful it must be conducted on an area-wide basis, particularly for highly mobile pests like *H. armigera*. In Australia, a strategy where pyrethroid use is restricted to defined periods during the growing season, has been in operation since 1983 (Forrester and Cahill, 1987), and has effectively prevented field failures, despite steadily increasing resistance. Despite adherence to the strategy, pyrethroid resistance has continued to increase annually and field control has only been maintained with pyrethroid products because of tightly controlled rates and times of application. Factors contributing to the success of the Australian strategy, such as area-wide management, are consistent with farming conditions in developed countries.

In Andhra Pradesh area-wide management is likely to be extremely difficult in view of the large number of farmers involved and wide range of host crops grown at different times. Farmers are generally ill-informed as to the most appropriate management practices, application is often poor, tank mixes of different chemicals are frequent and the purity of some locally purchased chemicals has been questioned (Anon, 1990). Commonly, farmers do not scout their fields for eggs and only perceive *H.armigera* as a problem when larvae, or their damage, have become conspicuous. Control action is then less effective and selection for resistance more intense. It is hardly surprising therefore that resistance should appear under these conditions in a State which accounts for over 40% of pesticide sales in India (Anon, 1990) and where pyrethroids comprised 50-70% of all applications to cotton (Jayaswal, 1989).

In southern India, summer season (March-June) survival presents a potential weak link in the pest's life cycle. However, the increasing trend to grow host crops such as okra, eggplant and tomato under irrigation is almost certainly increasing survival over this period, as well as maintaining resistance when these crops are sprayed. Summer vegetables could well be an important contributory factor to the emergence of *H.armigera* as a major pest in cotton over the past ten years.

Clearly there is a need for IPM rationale, with room for major improvements in the efficiency of insecticide use. These would include need-based application, using thresholds for eggs and small larvae. A legislative, or incentive, system to restrict the use of pyrethroids on cotton, legumes and summer vegetabls during critical periods would also need to be implemented. In cotton, the potential and economics of varietal and agronomic changes to cotton crop management need also to be explored thoroughly.

## ACKNOWLEDGEMENT

Dr K N Mehrotra and A. Phokela (Indian Agricultural Research Institute, New Delhi) for providing the Delhi strain of *H.armigera*.

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