Insecticide Resistance Management : Past Successes & Future Prospects

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It has been 9 years now since the introduction of the Summer Crop Resistance Management Strategy in 1983/84 season. This voluntary Strategy has been well accepted by all segments of the industry and has underpinned the development of the thriving rural success story that is the Australian cotton industry.

For the first 6 years of the Strategy, there was no real need to change the format of the Strategy as resistance levels were being contained to manageable levels. However, resistance levels had been creeping up slowly year by year and in the winter following the 1988/89 season, it was decided that a change was needed, so the pyrethroid window was reduced from 42 to 35 days duration. This had the desired effect of splitting the single large Stage 3 peak into two smaller "twin peaks" (by separating the moth and larval selection phases). However, pyrethroid resistance levels were still considered to be too high and it was decided to introduce the commercial use of piperonyl butoxide (Pbo) in 1990/91 season. This synergist chemical has no toxicity in its own right but when added to a pyrethroid, overcomes the most important of the three pyrethroid resistance mechanisms present in *Heliothis armigera* moths and larvae. This had the desired effect of interrupting the rapid selection of moths within the Stage 2 window and in suppressing the height of the Stage 3 larval resistance peak. However, the pyrethroid resistance levels have still continued to climb inexorably (1991/92 levels slightly higher than 1990/91) and the pyrethroid resistance situation remains critical.

The various tactics described above have certainly been successful in delaying the resistance problem and allowing us to remain one step ahead of the problem. The resistance monitoring programme has been the key to this success as it has allowed the industry to assess the need and timing for change and its impact. We must continue to monitor the progress of the Strategy and the Cotton Research & Development Corporation should be commended for its continuing and unquestioning support for this research programme.

Recommendations for the Future

There are no real prospects for the introduction of new insect control technologies for at least the next 4-5 years. The first most likely new candidate will be the new synthetic chemistry (the pyrroles) from American Cyanamid followed slightly later by the possibility of genetically transformed transgenic cotton engineered to express the Bt toxic protein. In the meantime, we must continue to make do with what we have (i.e. chemical control measures such as the pyrethroids, endosulfan, organophosphates, carbamates, the chitin inhibitor Helix® and Bt as well as the range of non-chemical control measures such as cultivation of over wintering pupae, avoidance of late crops etc.). Substituting endosulfan for the ailing pyrethroids is not the answer as this is already leading to increasing resistance problems with endosulfan as well as potentially adding to the industry's environmental burden. Organophosphates, carbamates and chitin inhibitors all have their various drawbacks (eg. lack of contact action, mercaptan odour drift, aquatic invertebrate toxicity, narrow spectrum of pests controlled, high cost etc.) and are only a partial answer. Bt has proven to be and will continue to be, very useful in mixtures with pyrethroids and endosulfan for use as a "safety net" to pick up pyrethroid and endosulfan resistant *Heliothis armigera* larvae which come through those sprays. Improvements in Bt technology (eg. better strains, formulations etc) and a lowering of price (through increased competition, removal of import duty etc.) will result in conventional Bt becoming a major component of future *Heliothis* control in cotton, both alone and in mixtures.

However, the steadily increasing resistance levels necessitate further action, particularly in the high *armigera* pressure areas in Queensland (eg. Emerald and St. George). With no new technologies available, the options are very few and the only one which I would be confident of proposing at this point in time is the advancement of the Stage 2 pyrethroid window by say 10 days to start Jan 1st instead of Jan 10th. The disadvantage of this is that it will result in higher Stage 3 costs at the end of the season (Stage 3 would start Feb 4 instead of Feb 14). However the advantages will be :-

- better utilisation of the pyrethroids by avoiding late season resistant *Heliothis armigera* and targeting earlier susceptible *Heliothis punctigera* populations.

- overcoming potential problems with poor control by endosulfan during possible heat-wave periods during the Jan 1-10 period.

The proposed earlier use of the pyrethroids should not increase the mite problem excessively. However, sensible early season (Oct-Dec) pest management decisions will be critical to keep the potential mite risk low while the availability of the new miticide propargite will also prove a useful backup if mite problems occur.

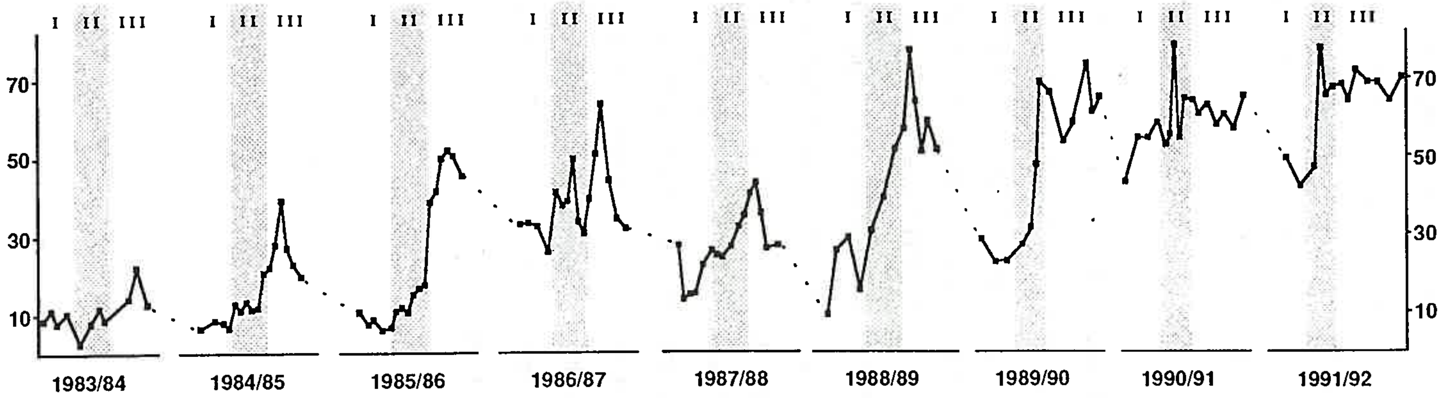
The development of the rapid field-based *Heliothis armigera/punctigera* identification kit has the potential to radically alter the current Summer Crop Resistance

Management Strategy. If it proves to be a simple, rapid and reliable field test, it will give growers and consultants the ability to determine the species composition of Heliothis egg or larval infestations on a field by field basis. Pest control decisions could be fine tuned according to the *punctigera/armigera* ratio and pyrethroids avoided when *armigera* populations dominate. This would give growers and consultants much more flexibility and would allow them to exploit the benefits of the pyrethroids much more by targeting them to susceptible *H. punctigera*. Of course there would still be a need for a general overriding recommendation that pyrethroids should not be used before, say Christmas, in order to avoid flaring mites, aphids or whitefly.

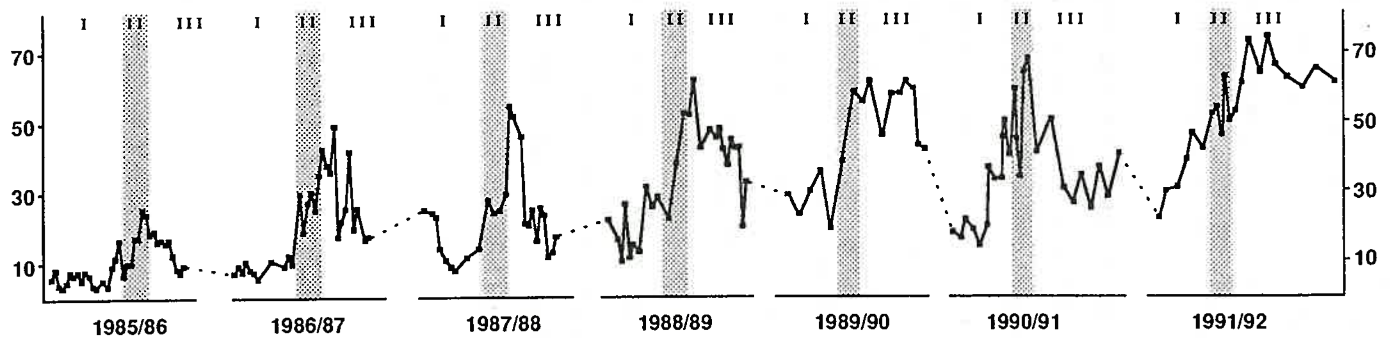
New Technology Use Tactics

The new technologies referred to above (pyrroles & transgenic cotton) will undoubtedly appear on the cotton insect control scene at a time when present technologies will be stretched to their limits. There will be a strong temptation to overuse these new technologies (remember when the synthetic pyrethroids first arrived on the scene in the late 70's when DDT, DDT/Toxaphene, endosulfan and carbamate resistance were a fact of life). These new technologies should and must be exploited, but sensibly, for the long term benefit of the Australian cotton industry. They should be used sparingly and wisely so that they will still be useful technologies in 50 years or more (just imagine the value of the synthetic pyrethroids to the Australian cotton industry today, if they still worked as well now, as they did when they were first introduced). These new technologies will most likely be relatively expensive when first introduced but will undoubtedly be cheaper in 10-20 years time (compare the relative price of pyrethroids now and when they were first introduced). This is all the more reason to preserve their effectiveness indefinitely.

Namoi/Gwydir --- % Pyrethroid Resistance



Emerald --- % Pyrethroid Resistance

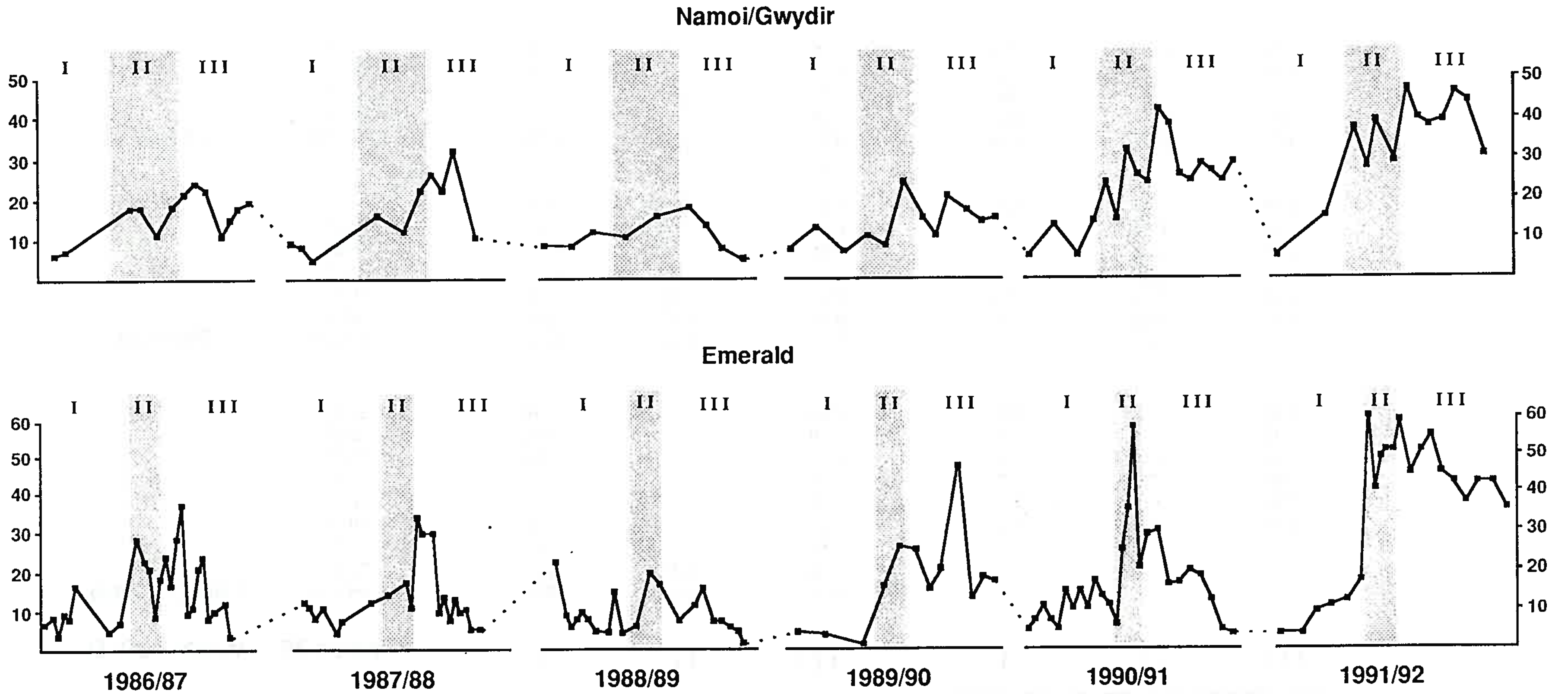


Weekly pyrethroid resistance in *Heliothis armigera* from the Namoi & Gwydir river valleys of northern New South Wales and the Emerald Irrigation Area of central Queensland for the 9 seasons since the introduction of a curative Resistance Management Strategy (for Stages I, II and III) (7 seasons only at Emerald). Results expressed as the percentage of larvae (reared from field collected eggs) surviving the fenvalerate discriminating dose (0.2µg per 30-40 mg larva).

1989/90, 1990/91 & 1991/92 Stage II pyrethroid windows 35 days duration; all others 42 days.

Piperonyl butoxide used as a commercial pyrethroid synergist from 1990/91 season onwards.

Endosulfan — % Resistance

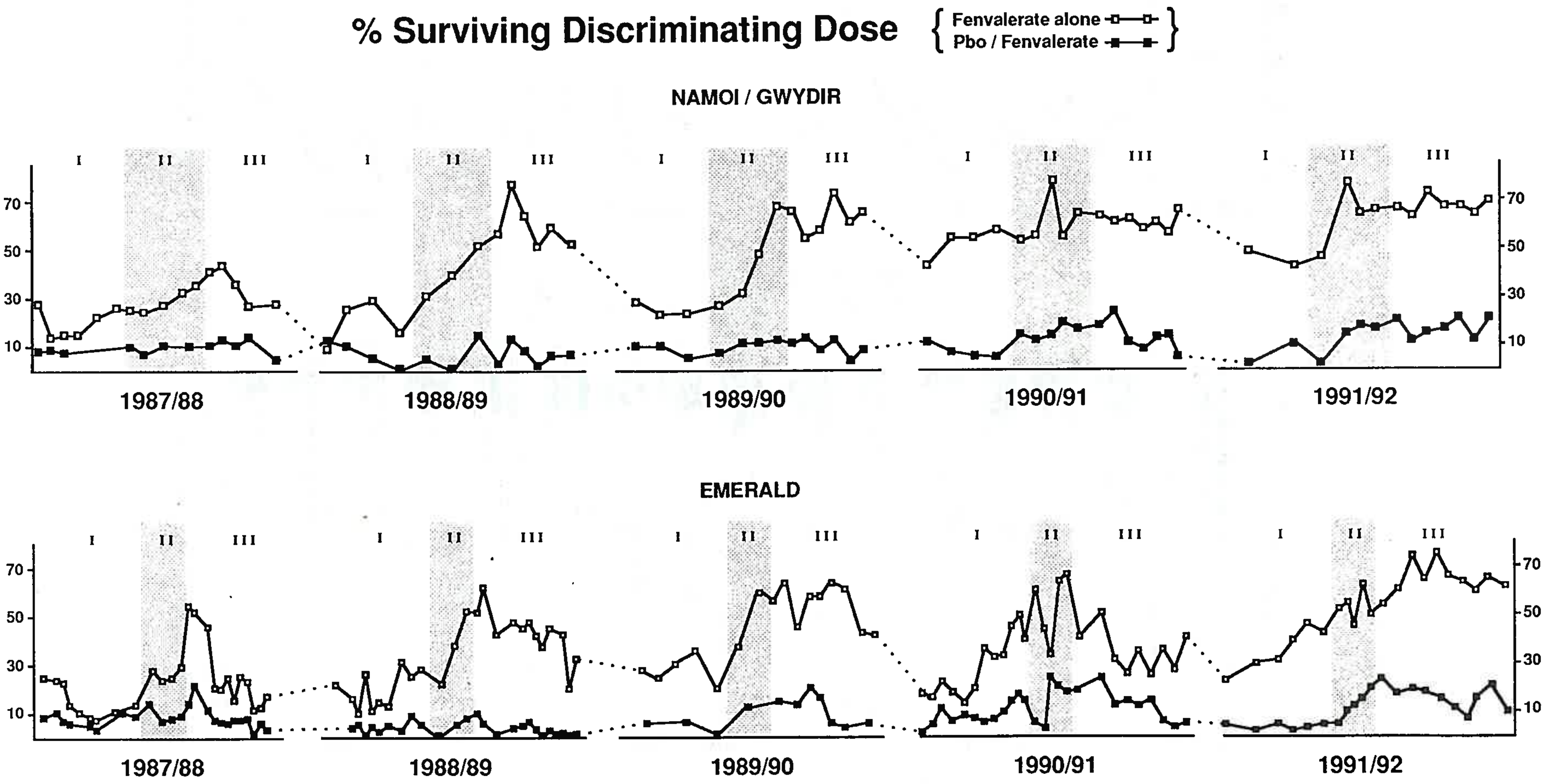


% SURVIVING DISCRIMINATING DOSE

STUDY AREA	SEASON	FENVALERATE I	FENVALERATE II	FENVALERATE III	ENDOSULFAN I	ENDOSULFAN II	ENDOSULFAN III
Namoi/Gwydir	1983/84	9.3	9.5	14.6	-	-	-
	84/85	7.5	12.9	27.9	-	-	-
	85/86	7.8	13.0	44.5	-	-	-
	86/87	32.2	36.7	42.9	7.1	16.7	20.1
	87/88	19.8	30.1	38.4	7.3	17.6	23.0
	88/89	19.6	42.4	60.7	8.8	13.2	10.6
	89/90	24.7	45.3	62.5	9.2	14.8	15.9
	90/91	55.7	61.1	61.5	12.2	22.7	31.3
	91/92	46.0	64.1	68.4	9.2	32.4	40.6
Emerald	1985/86	6.8	17.1	14.4	-	-	-
	86/87	8.8	26.5	29.8	7.7	20.6	17.3
	87/88	15.9	27.1	27.0	9.5	14.3	13.7
	88/89	19.8	38.7	44.3	8.1	13.6	7.1
	89/90	27.9	44.6	54.6	3.1	21.0	20.9
	90/91	24.7	52.2	34.5	10.1	37.1	16.0
	91/92	32.1	52.7	62.1	7.9	50.5	47.3
Inverell	1987/88	10.2	20.4	19.0	11.3	10.5	5.8
	88/89	21.9	28.9	41.7	9.4	4.8	5.4
	89/90	22.1	32.7	38.2	4.0	5.2	7.1
	90/91	47.8	34.6	45.1	3.4	8.5	10.8
	91/92	37.8	55.3	55.5	24.2	17.3	14.0
St. George	1991/92	-	80.2	90.9	-	60.9	67.4

Average pyrethroid and endosulfan resistance levels in *Heliothis armigera* for each Stage(I, II & III) of the Resistance Management Strategy, for 4 study areas (the Namoi and Gwydir valleys of northern NSW, the Emerald Irrigation Area of central Queensland, the St. George Irrigation Area of southern Queensland and a sample of the unsprayed refugia area centred on Inverell in northern NSW).

% Surviving Discriminating Dose



SUPPRESSION OF FIELD PYRETHROID RESISTANCE BY PBO