RESISTANCE MANAGEMENT IN AUSTRALIAN COTTON

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The Australian Field Crops Resistance Management Strategy has been in place now for 7 seasons. The impact of the Strategy on resistance levels is monitored in three areas; the Namoi and Gwydir river valleys of northern NSW (a temperate cotton monoculture), the Emerald Irrigation Area of central Queensland (a sub tropical mixed cropping area) and a sample of the unsprayed Refugia centred on Inverell in northern NSW. Resistance to both pyrethroids and endosulfan is assessed, as these two groups account for over 80% of the insecticides used against *Heliothis* spp. in Australian cotton. Studies with the oxidase inhibiting synergist piperonyl butoxide (Pbo) have indicated that the dominant mechanism of pyrethroid resistance in the field is via oxidative detoxification. This has led to the investigation of two possible chemical countermeasures for managing pyrethroid resistance: synergists and structurally modified pyrethroids (also called resistance breaking pyrethroids). A brief summary of each of these findings will be given followed by an outline of the future for managing pyrethroid resistance.

PYRETHROID RESISTANCE

Pyrethroid resistance levels have continued to increase slowly. The reduction of the pyrethroid window from 6 to 5 weeks has had a clear beneficial impact. The double selection which was occurring in the 6th week of Stage 2 has now been avoided and in fact, for the first time since the introduction of the Strategy, resistance levels dropped immediately after Stage 2. Normally they continue to increase and peak at a very much higher level in the 2nd - 4th week of Stage 3. However, after this initial decrease, they rose again later in Stage 3 due to the emergence of the survivors from larval selection in Stage 2. This resulted in a "twin peak" in both cotton study areas. The reduction in the window has slowed the increase in pyrethroid resistance, but it will not stop it. Of major concern is the very rapid rise in pyrethroid resistance within the window, experienced in the past two seasons. Resistance levels can change from satisfactory (about 25%) to uncomfortably high (70%) within 5 weeks. This is the critical period for growers and consultants as the pyrethroids are being used and high *armigera* pressure at this time, will result in poor field control. We must keep the pyrethroid window at 5 weeks and try to break the rapid adult moth selection cycle.

ENDOSULFAN RESISTANCE

The resistance levels at the start of the season were encouragingly low. However, levels had risen quite markedly towards the end of the season, particularly at Emerald where endosulfan use is higher. However, we have seen high levels in the past, and hopefully, they may return to low levels again by the start of the season. However, it is quite clear that we have incipient endosulfan resistance and that any increased endosulfan selection pressure on *Heliothis armigera* will probably tip the balance. We must retain the efficacy of endosulfan and avoid a return to the endosulfan resistance problems of the mid 70's. We need to keep the pyrethroids working in Stage 2, to avoid the increased use of endosulfan at this time of increasing *armigera* pressure.

PBO

Piperonyl butoxide has continued to give high levels of suppression of field pyrethroid resistance in all areas, last season averaging about 75% suppression during the critical Stage 2 pyrethroid window. Pbo is not effective on the intractable nerve insensitivity resistance mechanism and this is seen as the low level of residual resistance (usually less than 10%) left after adding Pbo to pyrethroids. Research has continued on developing light stable formulations of Pbo but so far, no improvement has been made over the currently available commercial formulations. Residual activity at 8:1 (Pbo:pyrethroid) is about 1 day while increasing the rate of Pbo (15:1) can push it out to perhaps 2 days. It would also help to apply Pbo in the early evening, to allow maximum exposure to the nocturnal moths before any degredation by sunlight.

RESISTANCE BREAKING PYRETHROIDS

A pyrethroid, which was shown to overcome metabolic resistance in a laboratory strain of resistant larvae, was tested last season on field collected material. It was shown to be as effective as the pyrethroid / Pbo mix on both moths and larvae. To be fully effective, a Resistance Breaking Pyrethroid needs to satisfy the following 5 requirements. It must :-

- resist metabolic detoxification by resistant *Heliothis armigera*
- be light stable
- have low mammalian toxicity
- be a relatively active compound (effective at or less than 20-80 g ai / ha)
- must have persistence (i.e. low volatility)

We do not yet have a pyrethroid which meets all 5 criteria but I believe it is only a matter of time before we do. Commercialisation of that molecule will then be the major obstacle.

FUTURE

In the longer term, we can probably look forward to new effective chemical groups, improved biological pathogens and genetically engineered host plant resistance. In the meantime, we must make do with our currently available limited resources. We must utilise the full range of control techniques. These are :-

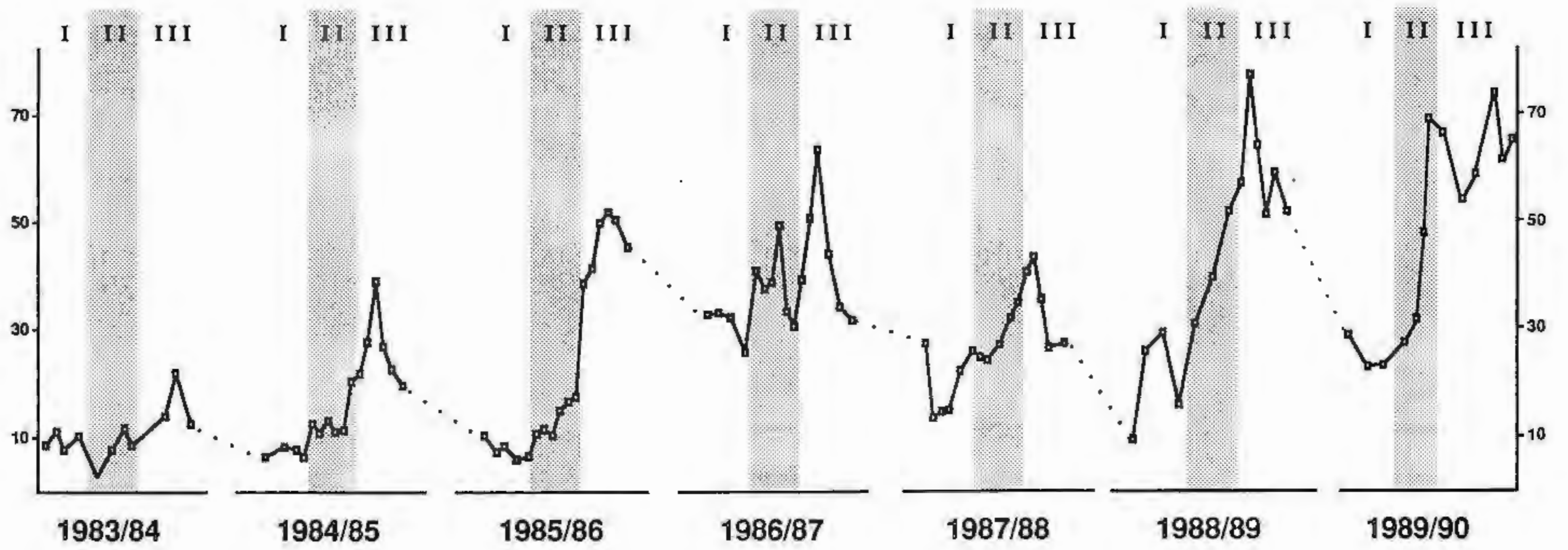
1) Chemical
- continue to follow the rotation Strategy
- use mixtures of ovicides when egg pressures warrant
- target sprays to egg hatch
- avoid pyrethroids during high *armigera* pressure
- add Pbo to the second pyrethroid spray to disrupt the rapid adult selection cycle
- use mixtures of bacterial pathogens (eg. *Bacillus thuringiensis*) with conventional insecticides

2) Biological
- use soft chemicals early (eg. endosulfan, thiodicarb and *B.t.)* to preserve the maximum benefit from early season biological control agents. This also prevents flaring of secondary pests such as mites and whitefly.
- utilise host plant resistance wherever possible (eg.okra leaf varieties offer some degree of control, particularly for mites).

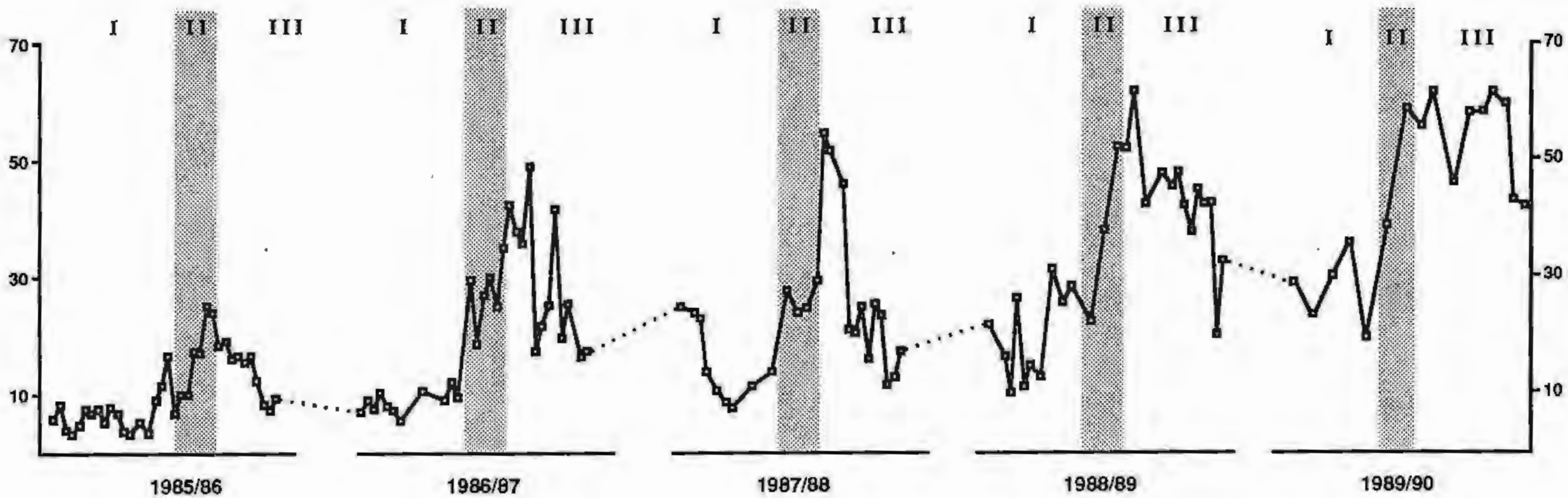
3) Cultural
- grow early maturing crops to avoid late season *armigera* problems (similarly, new investments in cotton production should ideally be located in the western areas of the cotton belt where *armigera* is much less of a problem).
- avoid unfavourable cropping patterns conducive to a buildup of *armigera* (eg. December flowering corn and sunflowers in predominantly cotton areas)
- cotton crop residues should be thoroughly cultivated to minimise survival of overwintering pupae

The key to managing resistance in *Heliothis armigera* in the future will be to vary the control practices so that the selection pressure will be insufficient for *armigera* to develop resistance to any one control measure. This should be the basis for long term, sustainable, economic pest control in cotton.

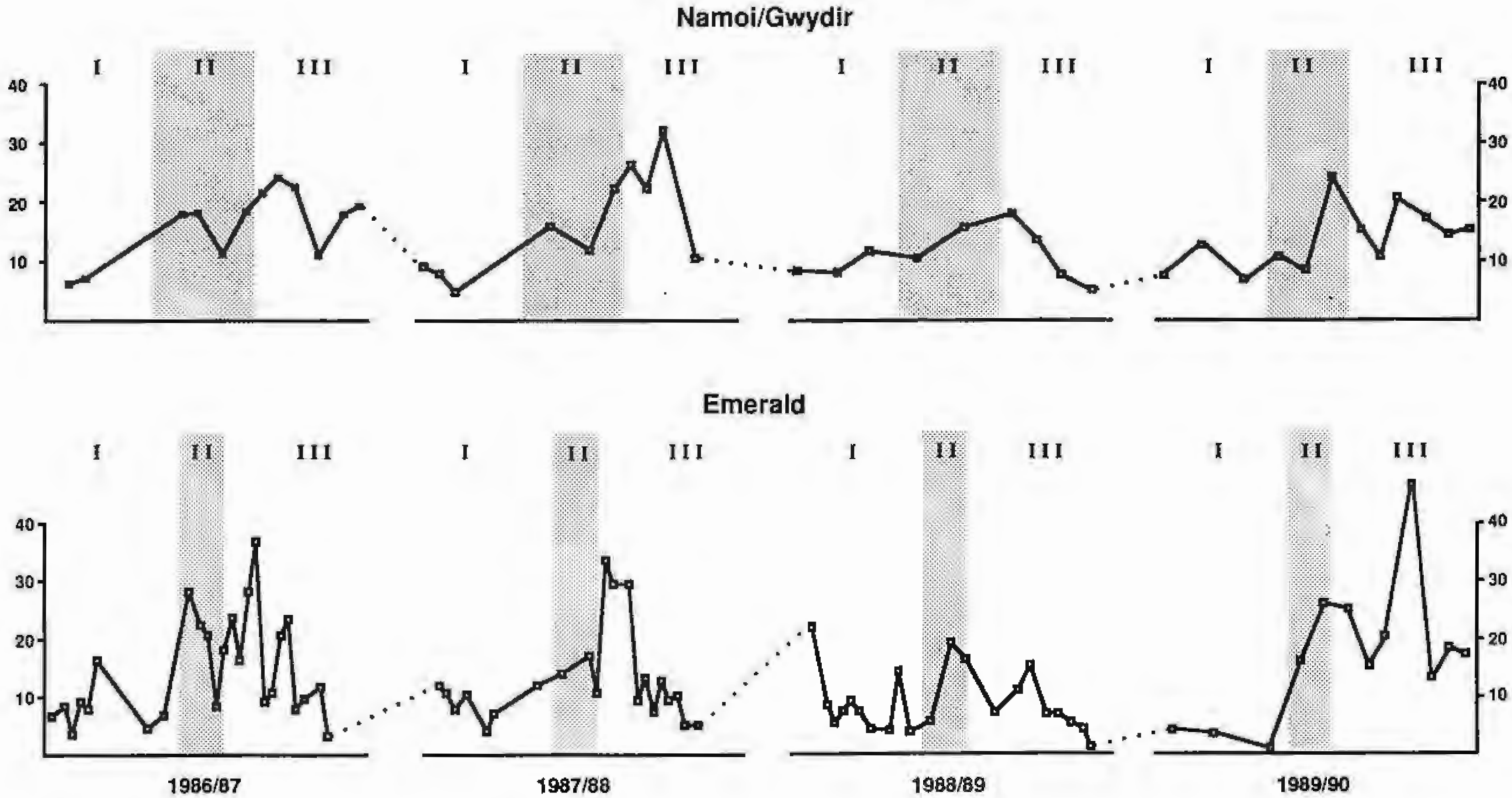
Namoi/Gwydir --- % Pyrethroid Resistance

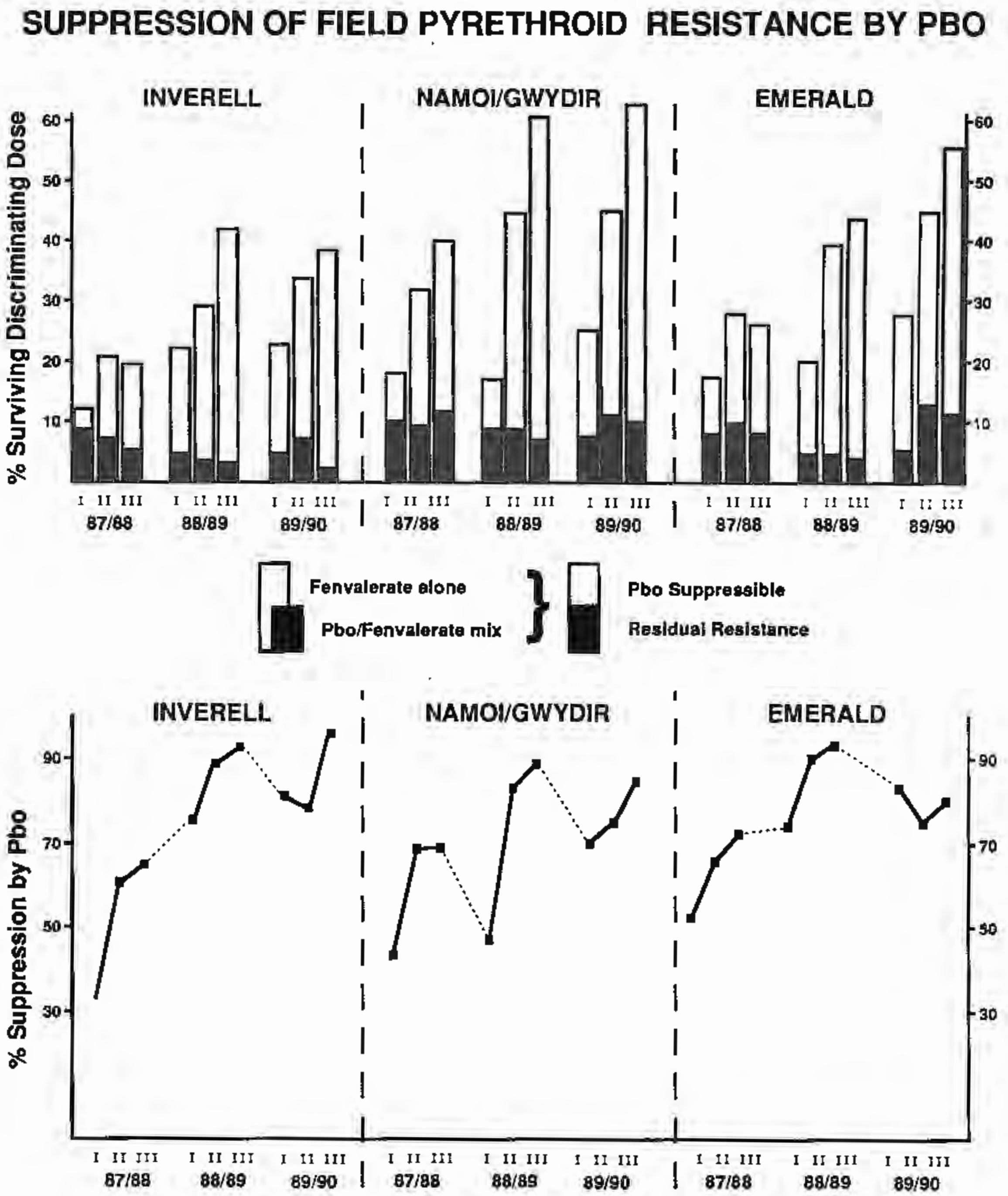


Emerald --- % Pyrethroid Resistance



Endosulfan — % Resistance




SUPPRESSION OF FIELD PYRETHROID RESISTANCE BY PBO
INVERELL
NAMOI/GWYDIR
EMERALD
% Surviving Discriminating Dose
60
50
40
30
20
10
I II III
87/88
88/89
89/90
Fenvalerate alone
Pbo/Fenvalerate mix
Pbo Suppressible
Residual Resistance
% Suppression by Pbo
90
70
50
30

Suppression of Field Pyrethroid Resistance by Pbo and a Resistance Breaking Pyrethroid - Namoi/Gwydir 1989/90