MANAGEMENT OF RESISTANCE IN *HELICOVERPA ARMIGERA* IN AUSTRALIA

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It has now been 11 years since the introduction of the Insecticide Resistance Management Strategy in the 1983/84 season. Continued monitoring of resistance levels in ***Heliothis armigera*** during that time has given the following results:-

Pyrethroids
- High resistance in all areas. Still increasing at Emerald, stable in the Namoi/Gywdir and St. George
- No real benefit in continuing to manage resistance in ***Heliothis armigera*** but still useful for control of *Heliothis punctigera*

Endosulfan
- moderate resistance levels but less stable than pyrethroid resistance
- resistance declining at St. George over the last three seasons due to reduced endosulfan use (6 down to 4 sprays, replaced by pyrethroids)
- still of benefit to manage resistance
- key product for early/mid season control of Heliothis without flaring mites but doesn't like hot weather

Profenofos
- low level resistance but increasing, especially at St. George
- is now a key product for ***Heliothis armigera*** control mid/late season
- some restrictions on use necessary now
- if resistance levels continue to rise, then further restrictions (eg. use in Stage 2 only) may have to be introduced

Thiodicarb
(Larvin)
- low resistance levels at present
- no evidence of increase this season
- key product now and later on for late season control in transgenic cotton
- no major restrictions necessary as yet but need to monitor closely

Helix
- no resistance as yet
- residual insect growth regulator which works through ingestion, soft on predators and parasites
- product of choice for long residual control after cut-out
- do not use too early (loss of residual through growth dilution)
- do not overuse, residues can be toxic to aquatic invertebrates
- will be the key product for late season control of *Heliothis* in transgenic cotton

Bt
- no resistance as yet
- key product for mixtures with endosulfan, thiodicarb and pyrethroids in early/mid season
- use too low at present to prejudice successful future release of Bt transgenic cotton
- no major restrictions necessary at the moment

Dicofol
(Kelthane)
- no resistance as yet
- contact miticide, therefore best results with properly set up ground rigs
- unique chemistry, therefore use early season to take pressure off propargite

Propargite
(Comite)
- the key miticide in cotton
- no resistance in cotton as yet

- long residual miticide which works well from the air, doesn't mind hot weather
- there is a resistance risk if overused (eg. two propargites three weeks apart could allow for selection for resistance in 3-4 generations of mites)

Profenofos (for mites)
- some resistance, variable efficacy
- translaminar (across the leaf) activity on mites
- best as break chemical if multiple mite sprays necessary

Bifenthrin (Talstar)
- contact pyrethroid active on mites as well as Heliothis
- good coverage needed by air to obtain best miticidal results
- no resistance in mites yet but potentially a high resistance risk product on mites
- good break chemical if multiple mite sprays necessary

Resistance Strategy for 1994/95

The Resistance Management Strategy is reviewed each year. A series of meetings are held throughout the cotton growing regions at the end of each season. The latest testing results and the format for the next season's Resistance Management Strategy are discussed. The final format for the Strategy is endorsed at an industry meeting in late June/early July each year, so that there is sufficient time for the agrochemical industry to organise stocks for the following season. This year's meeting endorsed a three stage Strategy based on calendar dates rather than crop growth stages (except for raingrown cotton in central Queensland). For the first time, miticides have been included and there will be a significant extension campaign to promote the cultivation of overwintering pupae. The LepTon™ Test Kit will play a key role in helping to decide the appropriate combinations etc. for pyrethroid and endosulfan sprays. Guidelines for using the LepTon Test Kit have been updated for the 1994/95 season and will be distributed at the 7th Australian

Cotton Conference and also published in the Cotton Pesticides Guide and the Australian Cottongrower. Pyrethroids will be allowed in Stage 1 (maximum of one spray only) to cater for early heatwave conditions or sustained heavy mirid pressure. However, they should only be used early if absolutely necessary, as early pyrethroid use has the potential to flare secondary pests (particularly mites) and to disrupt IPM programmes forcing growers onto the 'pesticide treadmill'. The insect growth regulator chlorfluazuron (Helix®) should not be used too early and is best restricted to one late season spray at cut-out (that is when plant growth slows down and the long residual activity of this product can be best utilised). Because of its specific toxicity to caterpillars, Helix will allow parasites and predators to thrive late season and to reduce the carryover of overwintering resistant *Helicoverpa armigera*. As such, it will also prove to be a key product for late season control of *H. armigera* in transgenic cottons.

Economics of resistance management

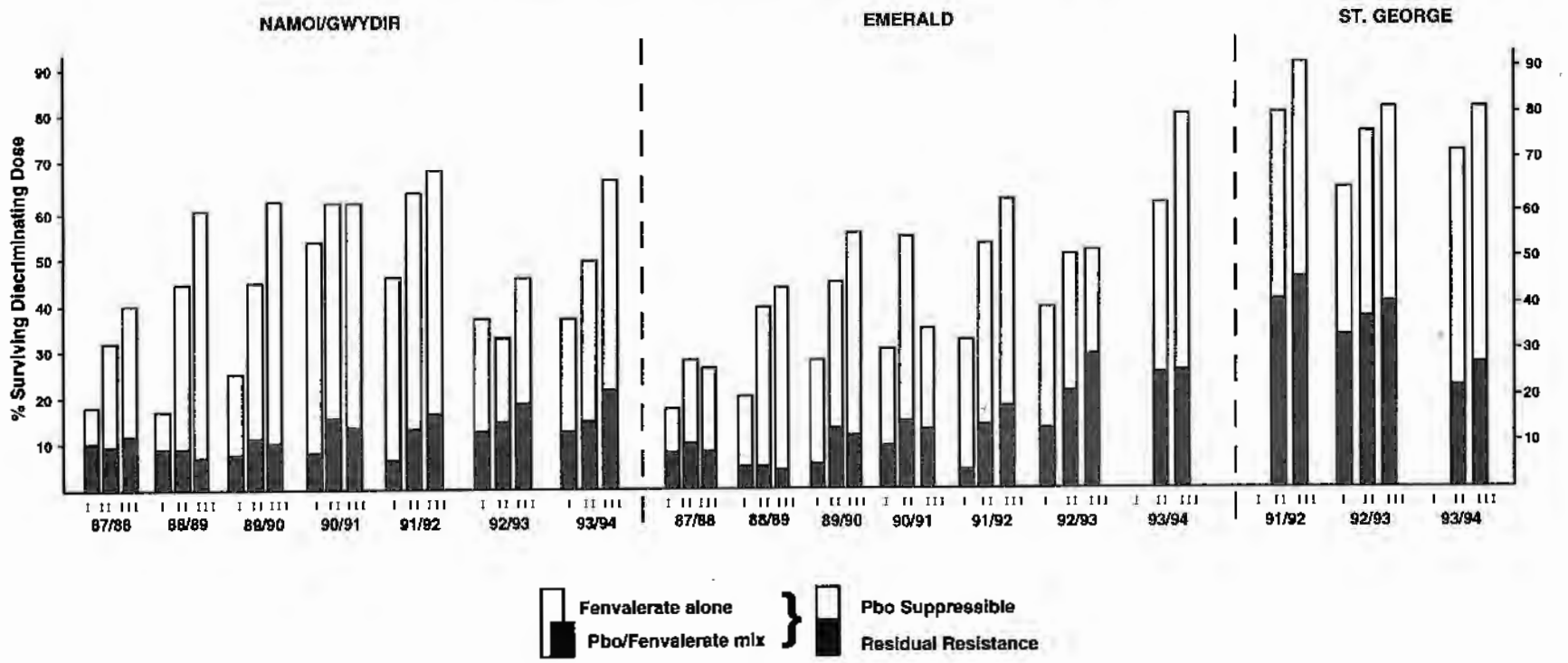
The economic consequences of uncontrollable insecticide resistance is described in two case studies. The analysis of the last five seasons of commercial cotton production on the Ord River scheme clearly indicates the increasing costs of production and consequent declining profitability. On a broader scale, the comparison of the Thai and Australian cotton industries, shows the economic consequences for a nation unable to contain its resistance problem.

% SURVIVING DISCRIMINATING DOSE

STUDY AREA	SEASON	FENVALERATE			ENDOSULFAN			PROFENOFOS		
		I	II	III	I	II	III	I	II	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	-	-	-
	92/93	33.9	34.0	41.9	24.7	35.2	27.7	-	0.9	0.2
	93/94	31.3	50.3	66.1	30.5	32.2	32.6	-	0.7	2.0
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	-	-	-
	92/93	40.2	50.6	59.1	25.9	51.6	59.5	-	-	1.1
	93/94	66.0	61.8	79.8	50.0	48.7	52.3	-	-	-
Inverell	1987/88	10.2	20.4	19.0	11.3	10.5	5.8			
	88/89	21.9	28.9	41.7	8.4	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			
	92/93	-	-	-	-	-	-			
St. George	1991/92	-	80.2	90.9	-	60.9	67.4	-	-	-
	92/93	63.7	76.0	80.4	29.9	59.7	57.5	-	1.4	3.7
	93/94	-	71.2	81.8	-	45.4	34.7	-	-	11.4

Average pyrethroid, profenofos (Curacron®) 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).

SUPPRESSION OF FIELD PYRETHROID RESISTANCE BY PBO



COTTON RESISTANCE MANAGEMENT STRATEGY for 1994/95 season

Heliothis & Mites

Stage I (Dec 20)	Stage II	Stage III (Feb 1)	Post-harvest
ENDOSULFAN - USE LEPTON TEST KIT TO AVOID HELIOTHIS ARMIGERA			Cultivate to destroy over-wintering pupae as soon as possible after picking and certainly by no later than the end of August
PYRETHROIDS - MAX 1 SPRAY IN STAGE I - USE LEPTON TEST KIT TO AVOID HELIOTHIS ARMIGERA - CHECK FOR MITES, PARTICULARLY IN STAGE I - NO CONSECUTIVE TALSTARS			
Bt			
THIODICARB - DO NOT USE AS LAST SPRAY			
		HELIX - MAX OF 2 - AFTER CUT-OUT (approx 1 open boll per metre)	
	PROFENOFOS - MAX OF 3, INCLUDING MIXTURES		
DICOFOL			
		PROPARGITE - MAX OF 2, NON-CONSECUTIVE	

No restrictions for other registered products.

Stage 2 dates for central Queensland
- **irrigated (start Dec 15, finish Feb 1)**
- **raingrown (start first flower, finish cut-out)**

Proposed future logo for on-going extension programmes etc. to promote cultivation of over-wintering pupae

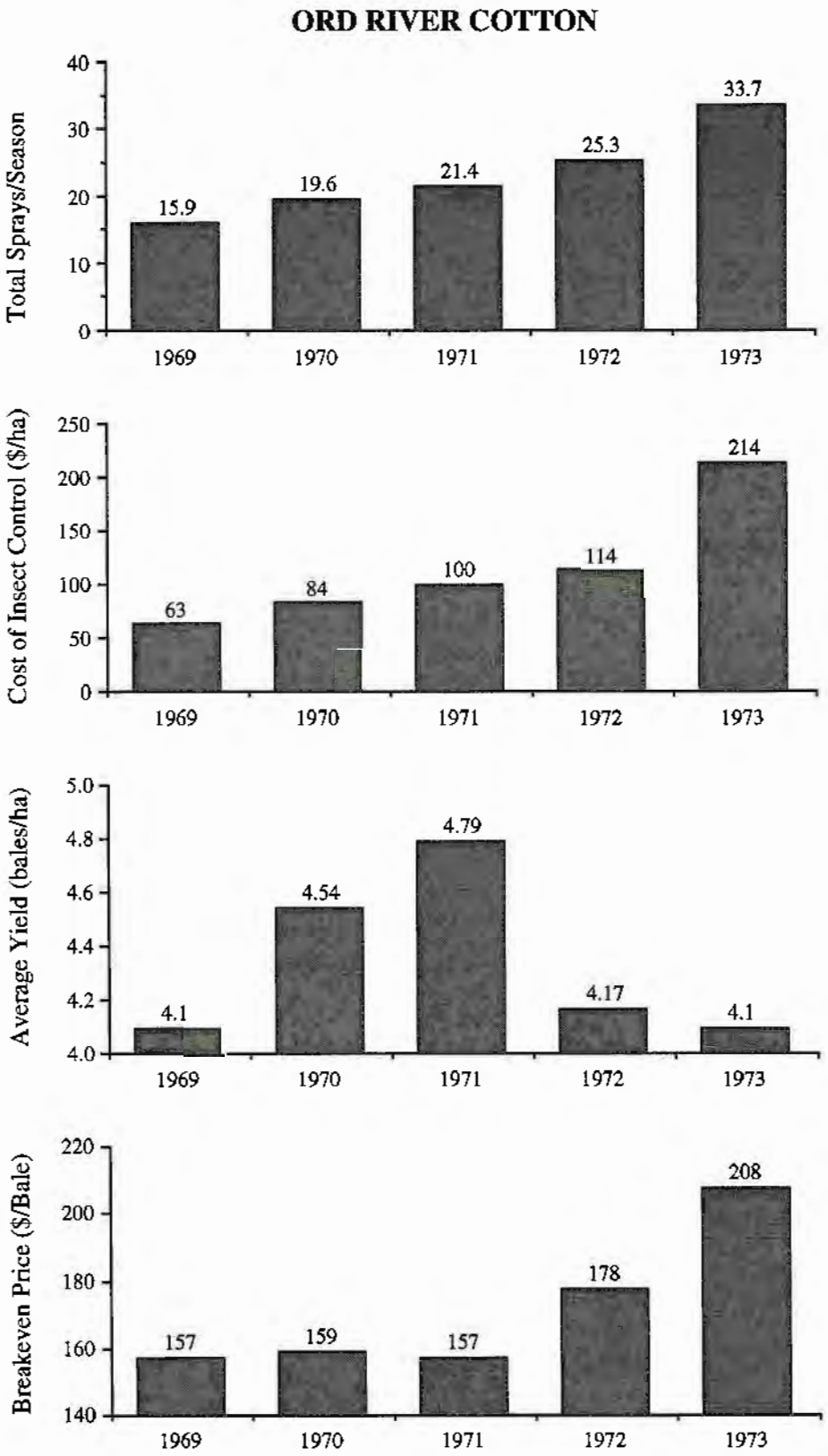
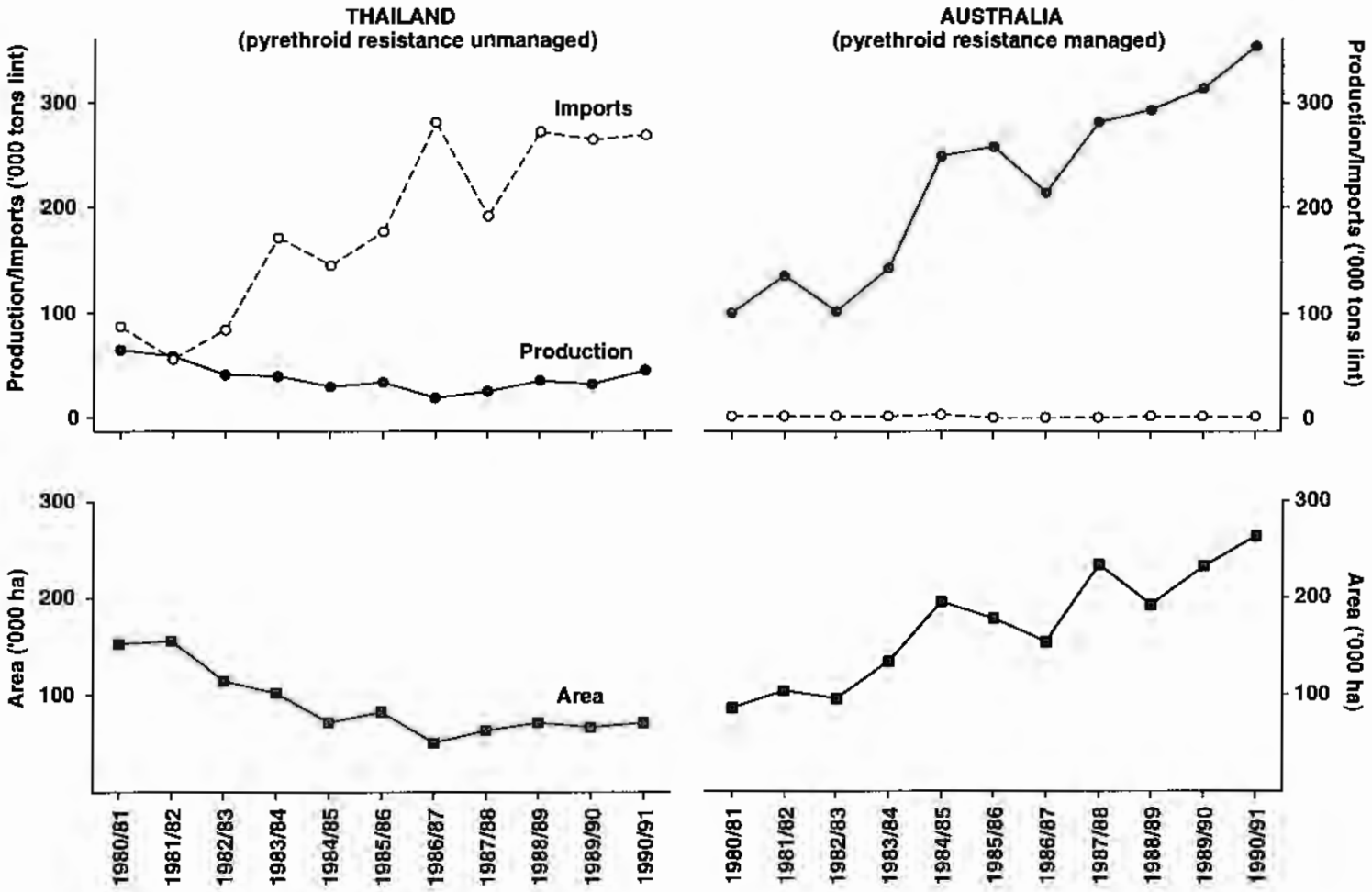


Fig 1. Economic impact of DDT resistance in *Heliothis armigera* on cotton production in the Ord River valley of north-western Australia, in the 5 seasons prior to the abandonment of cotton growing in the area. Data derived from Hearn (1975).



Impact of pyrethroid resistance in the cotton bollworm *Heliothis armigera* on the Australian and Thai cotton industries (data taken from Cox & Forrester, *Journal of Economic Entomology*).