EARLY SEASON DAMAGE - HOLES IN YOUR BOLLS OR YOUR BANK BALANCE?

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Early crop protection is a controversial subject in modern pest management. Grower magazines in Australia and the U.S. carry articles expressing firm opinions both for and against. Australian cotton growers remain divided on the issue. Two opposite philosophies have developed: the early strategists and the plant compensationists. Who should growers believe? What are the facts?

Why Dynamic Thresholds?

Evidence of crop compensation is abundant in the scientific literature (Table 1). In recent years studies of *Heliothis* thresholds have been done by Angus Wilson[6] and Ted Wilson [7,8, & unpublished]. These data, and information from SIRATAC field trials [2,4,5] have led to the formulation of the dynamic threshold concept in SIRATAC. Testing the dynamic threshold concept with Deltapine 61 (DP61) is described fully in the proceedings of the 1984 Cotton Growers' Conference [2] with the conclusion that over two years the concept saved an average of two sprays without loss of yield, and delays between 4 and 9 days.

SIRATAC users have the option of allowing the program to adjust *Heliothis* pest thresholds dynamically throughout the fruiting period of the crop. Predicted numbers of surviving bolls (computed by the SIRATAC fruit model) are compared with the manager's fruit plan (MFP). If the surviving bolls are ahead of the MFP and the fruit model calculates that yield loss will not occur, the pest thresholds are raised. In the pre-squaring phase thresholds are dynamic to the crop's timeliness with the planned first flower date.

Dynamic thresholds should:

1. Reduce early spray numbers;
2. Maintain total yield and quality
3. Not incur any extra late season sprays.
4. Minimise harvest delay .

Response to the dynamic thresholds has been varied, and most growers use SIRATAC without dynamic thresholds ("screwed down"). However, users of dynamic thresholds are keen proponents.

Table 1. The literature of plant compensation (from Brook, 1984[1])

Author	Year	Location
U.S.A		
Eaton	1931	Arizona
Hamner	1941	Mississippi
Dunnan *et al*	1943	"
Phillips *et al*	1979	Akansas, Mississippi
Walker *et al*	1979	Texas
U.S.S.R.		
Tanskiy	1969	Tadzhikistan, Turkmenia
Africa		
Coaker	1957	Uganda
McKinlay & Geering	1959	"
Morton	1979	Swaziland
Israel		
Kletter & Wallach	1982	
Australia		
Passlow	1959	Biloela
Passlow & Trudgian	1960	"
Evenson	1969	Ord River, W.A
A.G.L. Wilson *et al*	1972	"
Bishop *et al*	1977	Lockyer Valley, S.E. Qld
Room	1979	Namoi Valley, N.S.W.
L.T. Wilson (unpub.)	1979	"
Hearn *et al*	1981	"
A.G.L. Wilson	1981	"
L.T. Wilson & Bishop	1982	"
Ives *et al*	1984	"
Brook & Hearn	1984	"

New Developments and further testing

The advent of the new cultivars, Deltapine 90 (DP90) and Siokra, and the continued scepticism of many SIRATAC clients led to an expanded range of trials from 1984 to 1986.

The new trials are of three types:

(i) paired farm comparisons of SIRATAC with dynamic thresholds and SIRATAC
with low thresholds;

(ii) large-scale research trials of dynamic thresholds, low thresholds, and extreme protection;

(iii) small plot experiments, artificially simulating insect damage by square and tip removal.

These trials have produced data for and against the "compensationist" philosophy. They also show us the cotton plant is more complicated than we thought, and confirmed the researchers' dictum "Never repeat a good experiment ".

The 1985/86 Paired Farm Trials

These trials were conducted on eight commercial cotton fields across the Namoi Valley. Four sites were planted to SIOKRA, and four to DP90. The sites varied in size from 20ha to 60ha. Each site was divided into two large blocks; one block was managed using dynamic SIRATAC thresholds, while the other block was managed using base-level SIRATAC thresholds. Each site at each block was a separate SIRATAC Management Unit. Cultivations, water and fertilizer applications were applied uniformly across each site; the only difference between blocks at each site was the timing and frequency of insecticide applications, applied according to the recommendations of SIRATAC.

Table 2. Spray Numbers, 60% Open dates, and Yields(bales/ha) from Paired Farm Trials.

Variety	Farm	Sprays Low	Sprays High	60% Open Low	60% Open High	Yield Low	Yield High
DP90	D1	8	4	13 Mar	16 Mar	4.58	4.53
	D2	8	6	31 Mar	1 Apr	5.40	5.22
	D3	7	6	1 Apr	1 Apr	6.48	6.25
	D4	8	4	2 Apr	3 Apr	7.43	5.57
Average - DP90		7.75	5.0	27 Mar	28 Mar	5.97	5.39
SIOKRA	S1	6	5	3 Apr	2 Apr	5.73	6.42
	S2	8	4	29 Mar	30 Mar	6.72	6.49
	S3	6	4	31 Mar	31 Mar	7.03	6.66
	S4	6	7	26 MAr	23 Mar	8.32	9.04
Average - SIOKRA		6.5	5.0	30 Mar	29 Mar	6.95	7.15

The fruit model predicted that yield losses from *Heliotthis* feeding would occur if the thresholds remained dynamic after January 16. The thresholds reverted to their base levels after that date.

Table 3. Spray breakdown for Paired Farm trials.

	DP90		SIOKRA	
	Low	Dynamic	Low	Dynamic
Pre 16 Jan	3.75	1.25	2.75	1.5
Post 16 Jan	4.0	3.75	3.75	3.5
Total	7.75	5.0	6.50	5.0

Fig 1. Grade, Micronaire, and average Premiums ($/bale) for the Paired Farm Trials.

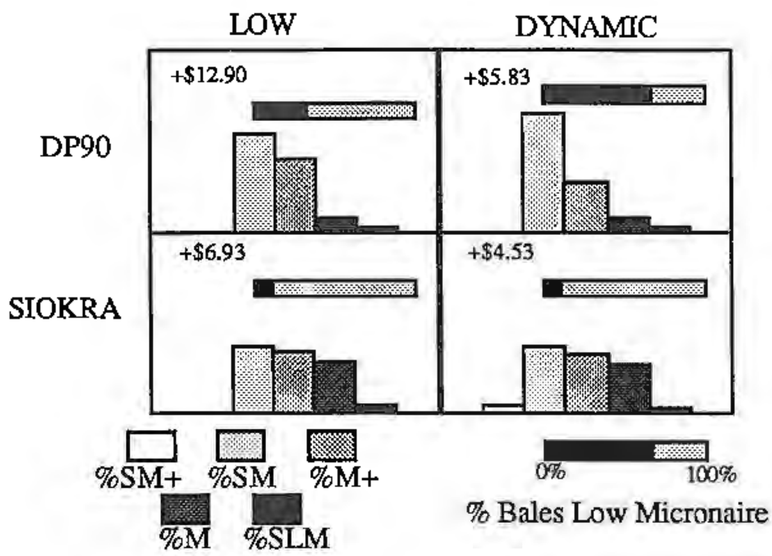
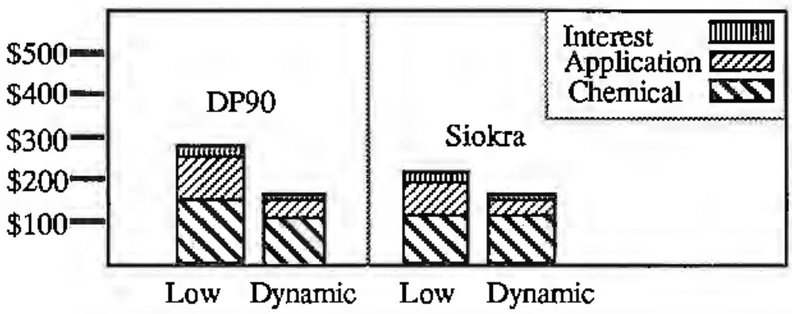


Fig 2. Spray Costs in $/ha for the Paired Farm trials



On average, with dynamic thresholds there was a saving of 1.5 sprays with SIOKRA, and 2.75 sprays with DP90. Additionally, at low thresholds SIOKRA recieved 1.25 fewer sprays than DP90. This is further evidence to SIOKRA's reduced susceptibility and increased tolerance to insect attack. In contrast to previous experiments, there were no delays in maturity in these trials.

There is no statistical difference between yields. The SIOKRA yields were higher than DP90 yields. With DP90 there is a trend for the high threshold plots to yield less. There were no quality differences between pest management treatments. Net returns were optimised by using dynamic thresholds on SIOKRA (see tables 4 & 5).

Table 4. Net returns ($/ha) at **$200/bale** for the Paired Farm Trials†

	LOW	DYNAMIC	
DP90	$1028	$947	
SIOKRA	$1238	$1304	No Discount
	$1099	$1161	-$20/bale Discount

Table 5. Net returns ($/ha) at **$300/bale** for the Paired Farm Trials †

	LOW	DYNAMIC	
DP90	$1625	$1486	
SIOKRA	$1794	$1932	No Discount
	$1585	$1876	- $20/bale Discount

The 1985/86 Large-Scale Research Trial (80ha field at Myall Vale)

Three spray treatments were applied to DP90, DP61, and SIOKRA. The spray treatments were:

1. Half SIRATAC base thresholds
2. Base level SIRATAC thresholds
3. Dynamic SIRATAC thresholds

Each spray treatment (72m wide) was replicated four times with all three varieties being present in 24m strips within each replicate. The pest management decision making was based on the DP90 insect counts. The insecticide treated areas were separated by 36m of unsprayed buffers.

The crop was slow to emerge, and substantial waterlogging occurred at the first irrigation. The crop then developed rapidly, and became quite vegetative and was delayed in maturity (ten days in comparison to other Namoi crops).

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† Footnote: Cost calculations.

Varietal Discount	= DP61 : -$25/bale discount
	= Siokra : -$20/bale possible discount
$/Bale average	= Base $/bale - Varietal Discount
Gross	= Yield x ($/bale average ± Quality adjustment/bale)
Net returns	= Gross - Spray Costs

Table 6. Yields (bales/ha) & 60% Opening dates for the Large-Scale Research Trial

	EXTREME	LOW	DYNAMIC
DP90	8.53 4 Apr	7.30 4 Apr	6.80 12 Apr
DP61	8.05 4 Apr	6.96 7 Apr	6.53 9 Apr
SIOKRA	9.80 1 Apr	9.42 1 Apr	9.19 4 Apr

Table 7. Sprays for the Large-Scale Trial

	EXTREME	LOW	DYNAMIC
Pre 16 Jan	9	3	1
Post 16 Jan	8	5	5
Total	17	8	6

Fig 3. Grades, Micronaires, average Premiums (+$/bale) and average Discounts (-$/bale) for the Large-Scale Trial

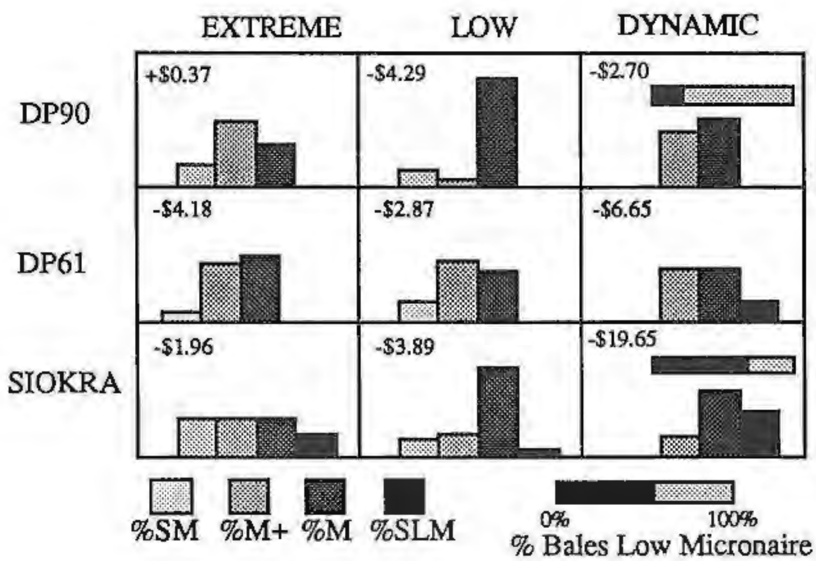

Fig 4. Spray Costs in $/ha for the Large-Scale Trial

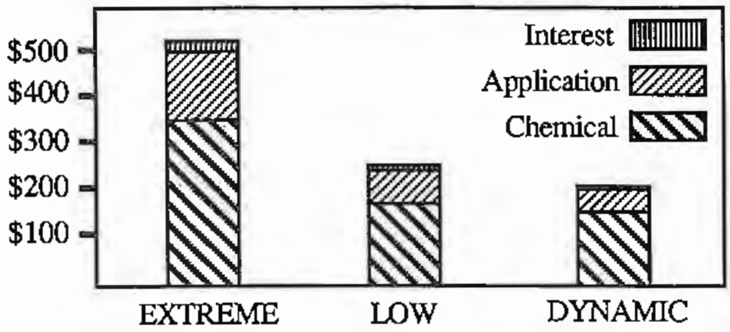

Table 8. Net returns ($/ha) at **$200/bale** for the Large-Scale Trial

		EXTREME	LOW	DYNAMIC	
DP90		$1174	$1170	$1128	
DP61		$840	$939	$886	
SIOKRA		$1406	$1588	$1444	No Discount
		$1209	$1400	$1261	-$20/bale Discount

Table 9. Net returns ($/ha) at **$300/bale** for the Large-Scale Trial

		EXTREME	LOW	DYNAMIC	
DP90		$2027	$1900	$1809	
DP61		$1645	$1635	$1539	
SIOKRA		$2386	$2530	$2363	No Discount
		$2190	$2342	$2180	-$20/bale Discount

The dynamic threshold treatment received only six sprays in comparison to the eight sprays of the low threshold treatment; the difference was in the number of the early season sprays.. The extreme treatment received seventeen sprays and combined with the large numbers of expensive chemicals resulted in a high cost of insect control.

There is a strong correlation with yield and increased spray numbers. Also, the quality of the dynamic threshold treatment was lower than the other threatments due to lower grade and some low micronaire bales. The response of both yield and quality is contrary with our previous experience. We suspect the lateness of the whole experiment (unconnected with pest management) was reponsible.

The yield differential between SIOKRA with extreme protection and with dynamic threshold protection was only one third the corresponding differential of DP90. The reduced response of SIOKRA to the numbers of insect sprays provides more evidence that this variety is both less susceptible and more tolerant to insect damage.

SIOKRA yielded more then DP90 over all spray treatments. Net returns were optmised with the low SIRATAC threshold treatment on SIOKRA.

The Small Plot Disbudding Trials

Small plot disbudding experiments were initiated to

(i) confirm Ted Wilson's results with DP61
(ii) investigate the effects of new varieties and reduced irrigation
(iii) further validate the fruit and *Heliothis* feeding models
(iv) provide detailed agronomic data of the crop's response to both pre-squaring and early squaring damage.

Damage at later periods in the fruiting cycle was not investigated in these experiments.

Squares and terminals were removed gradually over a two week period to mimic the devlopment of a *Heliothis* cohort from first instar through to large larvae. The required numbers of fruit to be removed were estimated from Ted Wilson's *Heliothis* feeding model which gives the relationship between fruit consumption and *Heliothis* numbers. Each experimental replicate consists of three parallel two-metre lengths of row. All rows were damaged, but fruit and yield were measured only on the middle metre of the middle row.

Small plot experiments allow us to simulate precisely the effects of known amounts of insect damage. The experiments are sprayed weekly to exclude most insect damage. Although tip removal of squares and terminals by tweezers does not exactly mimic the effect of insect damage, it is nonetheless applicable to extrapolate from these experiments to the real world. Our method of plant damage consists of removing the entire fruit or terminal body and does not allow for any nutrient remobilisation from the structures before abscission. The treatments are probably more extreme than real insect damage.

• Myall Vale 1984/85 Disbudding Trial.

7 Treatments, 7 Replicates; 5 & 10 Plants/metre; DP61;

Treatment	Description	Total Lint kg/ha	Days late*
Nil	Control at 10 plants/m (no damage)	2356	0
Light	20 squares removed from 12-24 Dec (2 larvae/m)	2467	3
High	59 " " " " " " (6 larvae/m)	2326	7
50%	50% of squares removed weekly to 10 Jan	1354	37
100%	100% of squares removed to 28 Dec	1765	20
Nil_5	Control at 5 plants/m	2521	1
High_5	59 squares removed from 12-24 Dec (6 larvae/m)	2521	8

* (Days late relative to the 60% Open date [13 Mar] of the Nil treatment)

With the exception of 50% and 100% treatments, there were no significant differences in yield. These two extreme treatments, far in excess of damage tolerated by SIRATAC were substantially reduced in yield, and maturity was quite delayed; a result at variance with published literature. The lint quality of these treatments was also reduced

• Myall Vale 1985/86 Disbudding Trial

8 Damage treatments, 6 replicates; 10 Plants/metre; DP61, DP90 and SIOKRA; Irrigation at 90mm and at 110mm deficits;

Treatments	Description
Nil	Control (no damage)
ET	Early tipping out, at 2 true leaf stage (7 Nov);
MT	Tipping out at 6 true leaf stage (22 Nov);
LT	Late tipping out at 1st square (3 Dec);
High	59 squares/m removed (18-30 Dec);
100%	100% of squares removed until 3 Jan;
ET*High	Combination of treatments ET & High;
LT*High	" " " LT & High.

N.B. Logistic considerations precluded all damage treatments being imposed over combinations of varieties and irrigations.

Table 10. Mean Yield (kg/ha of lint) of 1985/86 Myall Vale Disbudding Trial

DP90	DP61	SIOKRA
1995	1924	1957

Table 11. Yields of Irrigation by Damage Interactions (kg/ha of lint) for the 1985/86 Myall Vale Disbudding Trials
(average over all varieties)

	Nil	ET	MT	LT	High	100%	ET* High	LT* High
90mm Deficit	1981	1985	1981	1950	1907	1965	1947	1941
110mm Deficit	1976	1922		1965	1965			

Table 12. Days late relative to 60% Open Date (20 Mar) of the 90mm Deficit†† DP90 Control for the 1985/86 Myall Vale Disbudding Trials

	Nil	ET	MT	LT	High	100%	ET* High	LT* High
DP90	0	1		4	8	16	8	13
DP61	1				12			
SIOKRA	-6				-1			

†† Negative days late are days early.

Analysis of this experiment showed the only effects were due to variety and the interaction of irrigation and simulated damage. Apart from the lower yield of DP61 there were no significant differences. SIOKRA matured earlier than DP90.

• Darling Downs 1985/86 Disbudding Trial

Data courtesy of Peter Twine & Richard Lloyd, Q.D.P.I.

2 Trial Sites; 5 Damage treatment, 3 replicates; 10 Plants/m; DP90 & SIOKRA;

Treatments	Description
Nil	Control (no damage)
Light	20 squares per metre 13-23 Dec (2 Larvae/m);
Medium	39 " " " " " " (4 Larvae/m);
High	59 " " " " " " (6 Larvae/m);
100%	100% squares removed until 23 Dec.

Table 13 . Mean Yield (kg/ha of lint) of Damage Treatments by Variety for the Darling Downs Disbudding Trial #1

	Downs - Trial #1					
	Nil	Light	Med	High	100%	Ave.
DP90	1437	1437	1190	1457	1513	1415
SIOKRA	1533	1367	1430	1470	1527	1465

Table 14. Mean Yield (kg/ha of lint) of Damage Treatments by Variety for the Darling Downs Disbudding Trial #2

	Downs - Trial #2					
	Nil	Light	Med	High	100%	Ave.
DP90	1253	1257	1490	1467	1213	1336
SIOKRA	1263	1397	1283	1440	1310	1339

Table 15. Days late relative to the 60% Open date (10 Apr) of the DP90 Control for the Darling Downs Disbudding Trial #1

	Downs - Trial #1				
	Nil	Light	Med	High	100%
DP90	0	5	10	14	21
SIOKRA	-7	-13	-6	-1	14

Table 16. Days late relative to the 60% Open date (11 Apr) of the DP90 Control for the Darling Downs Disbudding Trial #2

	Downs - Trial #2				
	Nil	Light	Med	High	100%
DP90	0	2	-2	7	NA
SIOKRA	-4	-7	-13	-5	19

There were no significant yield differences. In Trial #1 the 100% treatment tended to have a lower micronaire, although it was not liable for micronaire penalties. In Trial #2 there was a decrease in staple length of the 100%-disbudding treatment which would have incurred a penalty. Again, the earlier maturity of SIOKRA is apparent.

• Biloela 1985/86 Disbudding Trial

Data courtesy of Peter Lawrence, Q.D.P.I.

3 Damage treatments, 8 replicates; 10 Plants/metre; DP90 and SIOKRA;

Treatments	Description
Nil	Control (No damage)
High	59 squares/m removed (16-27 Dec);
100%	100% of squares removed until 24 Dec;

Table 17. Mean Yield (kg/ha of lint) of Damage treatments by Variety for the Biloela Disbudding trial

	Nil	High	100%	Ave.
DP90	1536	1620	1585	1580
SIOKRA	1794	1738	1733	1755

Table 18. Days late relative to the 60% Opening Date (15 Mar) of the DP90 Control for the Biloela Disbudding trial

	Nil	High	100%
DP90	0	6	11
SIOKRA	2	7	10

SIOKRA yielded significantly more than DP90, but there were no significant effects of the damage treatments. The micronaire of the second maturity pick of the 100% treatment on SIOKRA was at the lower end of the acceptable range. In this trial, the SIOKRA was not earlier than DP90, as seen on the other experiments.

• Emerald 1985/86 Disbudding Trial

Data courtesy of Amanda Brumpton, SIRATAC Ltd, and John Ladewig, Q.D.P.I.

5 Damage treatment, 5 replicates; 10 Plants/m; DP90 & SIOKRA;

Treatments	Description
Nil	Control (no damage)
Light	20 squares per metre 9-23 Dec (2 Larvae/m);
Medium	39 " " " " " " (4 Larvae/m);
High	59 " " " " " " (6 Larvae/m);
100%	100% squares removed until 22 Dec.

Table 19. Days late relative to the 60% Opening Date (15 Mar) of the DP90 Control for the Emerald Trial

	Nil	Light	Med	High	100%
DP90	0	3	4	4	14
SIOKRA	-4	0	3	1	13

Unfortunately, yield data will not be available for the Emerald trial. However, there were no differences in the openboll counts amongst the damage treatments.

Summarising the Data:

The disbudding trials show that removal of 60 squares per metre during early squaring will not effect yield or quality, and results in approximately a seven day delay in maturity. This damage level is equivalent to 6 larvae/metre which is well in excess of the upper SIRATAC threshold. Total removal of all squares during this period results in unacceptable delays of up to three weeks; possible effects on maturity; and in one experiment, yield losses.

The large-scale trials appear to tell a different story on first examination. It is possible to dismiss the large-scale trial at Myall Vale as being unrepresentative and to suggest that the unfavourable yield and quality responses were somehow related to the lateness of the crop. With the paired-farm comparisons, dynamic thresholds worked well for SIOKRA, but DP90 was reduced in yield. In the trials SIOKRA showed characteristics of reduced insect attractiveness, increased tolerance to pest attack, and inherent earlier maturity. The unfavourable result with dynamic thresholds on DP90 was contrary to our expectations based on trials with dynamic thresholds on DP61.

The dynamic thresholds used is these experiments exposed DP90 to a longer duration of insect attack in the early squaring phase than was mimiced by the disbudding experiments. Users of SIRATAC need to reconsider the period of time for which dynamic thresholds apply in the early season with DP90. The current programming with SIOKRA appears to be reasonable.

Are delays a problem?

Many growers are concerned about the possible delay (1 - 9 days) caused by dynamic thresholds. Is uniform maturity across the farm desirable? Obviously, it is not possible to harvest the entire farm in one day. Therefore we suggest that dynamic thresholds be used on a portion (say 50%) of the farm and low thresholds be used on the rest. The SIRATAC management system is the best way of monitoring and controlling this strategy. Liberal watering and heavy applications of nitrogenous fertilizer can also produce as great or greater delays than dynamic thresholds[3].

Short-Season Situations:

We are still uncertain about the use of dynamic thresholds in short-season regions, limited water situations and late crops. Therefore we would make a conservative recommendation to limit the effect of dynamic thresholds in these situations until further information is forthcoming.

The dynamic threshold mechanism uses flower dates suitable to each region and furthermore the fruit model is specifically calibrated for each region and uses meteorological data local to that region. Therefore the system already imposes some inbuilt checks for short-season areas . Also, the current thresholds are continuously being adjusted according to the current fruiting status of the crop. This provides a further mechanism to ensure the pest threholds are relevant to the manager's preferred course of crop development (MFP).

Positive results from the Darling Downs disbudding trial and the Auscott Warren early protection trial (Auscott Ltd; Pers. com.) provide hope that there is scope in some short-season areas. The Downs trial and the 110mm deficit treatment in the Namoi showed that early damage does not necessarily reduce yield under reduced water input.

Implications for Resistance Management

One of the original aims of SIRATAC was to reduce the risk of insect resistance developing by minimising the number of spray applications. Dynamic thresholds assist in removing the selection pressure caused by numerous early sprays, particularly endosulfan.

Future Management Strategies:

Previous theoretical computer studies (unpub.) with feeding models and the SIRATAC fruit model have suggested a possible need to reduce mid-season thresholds. The extreme protection treatment in the Myall Vale large-scale experiment yielded highly. It is not possible to say whether the increased numbers of early sprays, the increased number of later sprays, or both, were responsible for the increased yield. If one combines the information from that experiment with the disbudding information, it could be hypothesised that a pest management strategy of dynamic thresholds with increased mid-season protection would have given the same result. It is hoped to test this interesting hypothesis in the future.

Conclusion:

On the basis of the last six years experience, we advocate the use of dynamic SIRATAC thresholds as a method of reducing spray numbers and consequently reducing costs, particularly with SIOKRA.

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