EFFECTS OF FRUIT FORM REMOVALS ON COTTON YIELDS IN CENTRAL QUEENSLAND

By T. PASSLOW, M.Sc.Agr.,* and K. G. TRUDGIAN, B.Sc.†

SUMMARY

During 1957-1959 four trials in both irrigated and rain-grown cotton were conducted in Central Queensland. Removals of all squares and bolls were carried out during eight weeks following the first burst of squaring, approximately three weeks after the appearance of the first squares.

Removals during the first four weeks did not affect yields. Maturing of replacement squares following removals during the next four weeks was dependent on length of season and growing conditions.

The effect of loss and damage among squares and bolls late in the season was demonstrated by an unusually severe *Heliothis armigera* (Hubn.) attack during March and the incidence of *Pectinophora scutigera* (Hold.) during 1958-59.

I. INTRODUCTION

In Central Queensland, cotton is sown from mid-October to early December. Early plantings usually give the best yields although these crops often suffer loss of squares and young bolls following either or both severe heat and insect attack during December and early January. This loss has been considered of major importance since the inception of the industry in Central Queensland, where *Heliothis armigera* (Hubn.) is the insect most commonly associated with fall of squares and bolls in December and early January. Passlow (1958, 1959), however, demonstrated that insecticide treatments for control of *H. armigera* during the early square production period had no influence on total yields although treatments increased the first pick. Second-pick yields were lower in sprayed than in untreated areas, where squares and small bolls lost to pest attack were replaced later in the season.

In the United States of America, Eaton (1931) studied plant reaction to early defloration and obtained yield increases following manual removal of early buds. Later, Dunnam, Clark, and Calhoun (1943) showed that removal of squares for periods as long as six weeks from first production had no effect on yields provided rainfall was above normal. In East Africa, McKinlay and

* Research Entomologist, Division of Plant Industry, Queensland Department of Agriculture and Stock.

† Agronomist, Division of Plant Industry, Queensland Department of Agriculture and Stock.

Geering (1957) and Coaker (1957) found that protection from insect attack during the first four months did not affect yields in early-sown crops, but gave yield increases in late crops.

These results and those of Passlow (1958, 1959), where plant recovery occurred following relatively low loss of early squares and young bolls, suggested the present investigations in which plant reactions to complete removals of fruiting forms were studied.

Four trials were carried out. Trials 1 (1957-58) and 3 (1958-59) were established in irrigated Miller 43-9-0 at the Biloela Regional Experiment Station, and Trials 2 (1957-58) and 4 (1958-59) in rain-grown Arkot 2-1 at Gracemere.

II. METHODS

Trials 1–4 were planted on October 15, November 7, October 14 and December 8, respectively, each as a 6 x 4 randomized block with a plot size of either 25 ft (Trials 1 and 2) or 20 ft (Trials 3 and 4) of two adjacent rows, 3 ft 6 in. apart.

In Trial 1 treatments were:

A: No removal of fruit forms.

B: Weekly removal of all fruit forms for two weeks commencing November 26 at the first burst of squaring, approximately three weeks after the appearance of the first squares.

C: Weekly removal of all fruit forms for four weeks commencing November 26.

D: Weekly removal of all fruit forms for six weeks commencing November 26.

E: Weekly removal of all fruit forms for eight weeks commencing November 26.

F: No removal of fruit forms.

In Trial 2 treatments were basically similar to those in Trial 1 except that removals were commenced on January 10, one week after the first burst of squaring, and carried out for 1, 3, 5 and 7 weeks in Treatments B, C, D, and E.

In Trials 3 and 4 treatments were:

A: No removal of fruit forms.

B: Removal of all fruit forms on December 16 in Trial 3 and February 4 in Trial 4, two weeks after the first burst of squaring.

C: Removal of all fruit forms on December 30 in Trial 3 and February 19 in Trial 4, four weeks after the first burst of squaring.

D: Removal of all fruit forms on January 14 in Trial 3 and March 4 in Trial 4, six weeks after the first burst of squaring.

E: Removal of all fruit forms on January 28 in Trial 3 and March 19 in Trial 4, eight weeks after the first burst of squaring.

F: No removal of fruit forms.

In each trial, all treatments except F were sprayed to prevent damage from insects, particularly *H. armigera.* The insecticides used were:

DDT.—An emulsion concentrate containing 25 per cent. *p.p'* isomer.

Parathion.—An emulsifiable preparation containing 25 per cent. w/v active ingredient.

DDT 0·1 per cent. was applied 11 times in Trials 1 and 2 and 12 times in Trials 3 and 4 at weekly intervals commencing November 26, January 10, December 9 and January 29 respectively. Parathion 0·05 per cent. was incorporated with the applications on February 25, March 7 and March 14 in Trial 2 and on March 13 in Trial 4 to prevent build-up of the mite *Tetranychus ludeni* Zacher. Thorough coverage to run-off was achieved at all applications, using a power-driven, hand-operated, twin-nozzle unit.

Trials 1–4 were harvested weekly from February 25 to July 2, March 5 to July 2, February 24 to June 29 and April 2 to July 10 respectively.

Results were assessed in terms of numbers of fallen fruit forms, production of fruit forms and yields.

All fallen forms were collected weekly from the inter-row space in each plot; totals of squares and bolls and numbers damaged by insects were recorded. Numbers of larvae of pest species found in damaged forms in Trials 2, 3 and 4 were recorded. These were predominantly *Pectinophora scutigera* (Hold.), with some *Earias huegeli* Rog. and *Dichocrocis punctiferalis* (Guen.) and a few *H. armigera.*

Fruit form production was calculated from the data on fallen forms and weekly records of squares, bolls and mature bolls on selected plants. A square became a boll when, following fertilization, the floral parts commenced to dry out and either fell or could be readily lifted away. A boll was mature when dried out. Mature bolls were divided into pickable (those carrying at least one lock of sound cotton), and unpickable (those carrying no sound cotton).

Prior to commencement of squaring, five (Trials 1 and 2) or four (Trials 3 and 4) representative plants were selected in each plot and weekly records of numbers of squares, bolls and matured bolls on each were taken. Weekly production of forms was calculated by subtracting the number of forms on the plants at the beginning of each week from that on the plants at the end of the week, and adding to this figure the calculated number of forms which fell from an equivalent number of plants during the week. It was assumed that the number of fallen forms collected was half the total fall from plants in a plot.

Harvesting was carried out weekly. Weight of seed cotton and numbers of pickable and unpickable bolls were recorded.

III. RESULTS

Results are presented in Tables 1–12. The inverse sine was used to transform percentage damaged fallen forms. Yields are expressed in the economic unit of pounds of seed cotton per acre, and where necessary are adjusted to an equal number of plants.

IV. DISCUSSION

(a) Trial 1

Despite large differences in numbers of fallen forms and in production of forms (Tables 1 and 2), no significant yield differences (Table 3) were obtained. These results are similar to those of Passlow (1958, 1959), who obtained higher production of forms in unsprayed than in sprayed cotton without yield differences. Good growing conditions were experienced throughout the trial; under these conditions recovery from loss of early fruit forms will occur irrespective of the cause of such loss.

TABLE 1

Trial 1. Total and Damaged Fallen Forms

Treatment	Mean per Plot	Mean Damaged	Damaged Forms (%)	
			Trans. Mean	Equiv. Mean (%)
No removal, sprayed	814	104·2	21·1	13·1
Removal for 2 weeks, sprayed	826	118·2	22·3	14·4
Removal for 4 weeks, sprayed	1,013	104·0	18·5	10·0
Removal for 6 weeks, sprayed	1,643	214·2	21·2	13·1
Removal for 8 weeks, sprayed	1,570	155·0	18·3	9·9
No removal, unsprayed	1,083	234·5	27·9	21·9
Necessary differences for significance 5%	200	36·2	2·7	
Necessary differences for significance 1%	276	50·1	3·7	

TABLE 2

Trial 1. Production of Fruit Forms

Treatment	Production per 5 plants		Date of Last Removal
	Total (Nov. 26–July 2)	From Time of Last Removal	
No removal, sprayed	330	330	..
Removal for 2 weeks, sprayed	370	356	Dec. 3
Removal for 4 weeks, sprayed	462	384	Dec. 16
Removal for 6 weeks, sprayed	812	545	Jan. 2
Removal for 8 weeks, sprayed	948	538	Jan. 13
No removal, unsprayed	435	435	..
Necessary differences for significance 5%	66	46	
Necessary differences for significance 1%	91	63·9	

The much higher production of forms obtained when removals were carried out for as long as six and eight weeks shows that the potential yield was increased. At the same time, however, fallen form numbers were comparatively higher in these treatments, indicating that the yields obtained in the no-removal/sprayed plots were the maximum for the conditions prevailing during the trial.

TABLE 3

Trial 1. Yields, Numbers of Plants and Mature Bolls

Treatment	Yield (lb/ac)	Plants per Plot	Mature Bolls		
			Total	Pickable	Unpickable
No removal, sprayed	1,618	48·2	766	578	188
Removal for 2 weeks, sprayed	1,612	49·0	789	585	204
Removal for 4 weeks, sprayed	1,748	48·2	715	604	112
Removal for 6 weeks, sprayed	1,506	49·0	788	599	190
Removal for 8 weeks, sprayed	1,506	48·0	828	659	170
No removal—no spray	1,668	47·8	765	591	174
Necessary differences for significance 5%	255	3·3	71	72	44
Necessary differences for significance 1%	353	4·5	98	100	62

(b) Trial 2

Significant yield increases are associated with the increased fruit form production following removals for periods as long as five and seven weeks (Tables 4 and 6). Field conditions were poor until mid-January, when good rainfall occurred; the remainder of the season was excellent. When removals were carried out for as long as five and seven weeks the plants were forced to produce their crop during this latter period. The no-removal/sprayed treatment gave better yields than the unsprayed treatment following an Heliothis attack during March. This demonstrates that pest attacks late in the season when replacement of fallen forms is most unlikely can cause economic losses (see Passlow 1958).

TABLE 4

Trial 2. Total and Damaged Fallen Forms

Treatment	Mean per Plot	Mean Damaged	Damaged Forms (%)	
			Trans. Mean	Equiv. Mean (%)
No removal, sprayed	679	140	26·8	20·3
Removal once, sprayed	528	90	24·2	16·9
Removal 3 times, sprayed	638	82	21·1	13·0
Removal 5 times, sprayed	1,041	118	19·8	11·5
Removal 7 times, sprayed	980	141	22·4	14·5
No removal, unsprayed	612	178	32·6	29·1
Necessary differences for significance .. 5%	173	43	2·9	
Necessary differences for significance .. 1%	239	59	4·0	

TABLE 5

Trial 2. Production of Fruit Forms

Treatment	Production per 5 plants		Date of Last Removal
	Total (Jan. 10–July 2)	From Time of Last Removal	
No removal, sprayed	372	372	—
Removal once, sprayed	361	361	Jan. 10
Removal 3 times, sprayed	511	414	Jan. 24
Removal 5 times, sprayed	830	568	Feb. 7
Removal 7 times, sprayed	1,243	628	Feb. 21
No removal, unsprayed	327	327	—
Necessary differences for significance .. 5%	159	113	
Necessary differences for significance .. 1%	220	156	

TABLE 6

Trial 2. Yields, Numbers of Plants and Mature Bolls

Treatment	Yield (lb/ac)		Plants per Plot	Mature Bolls		
	Observed	Adjusted		Total	Pickable	Unpickable
No removal, sprayed ..	2,074	2,075	38·0	820	752	68·0
Removal once, sprayed ..	1,980	1,981	38·0	732	702	30·0
Removal 3 times, sprayed	2,206	2,112	41·0	863	806	57·8
Removal 5 times, sprayed	2,671	2,688	37·5	1,054	995	59·8
Removal 7 times, sprayed	2,626	2,674	36·5	1,140	1,064	76·2
No removal, unsprayed ..	1,606	1,631	37·2	730	634	96·5
Necessary differences for significance .. 5%	284		4·7	127	112	26·9
Necessary differences for significance .. 1%	393		6·5	175	154	37·2

TABLE 7

Trial 3. Total and Damaged Fallen Forms

Treatmen	Mean from Time of Removal	Damaged Forms (%)	
		Trans. Mean	Equiv. Mean (%)
No removal, sprayed	673	20·5	12·2
Removal at 2 weeks, sprayed	617	16·2	7·8
Removal at 4 weeks, sprayed	501	13·1	5·1
Removal at 6 weeks, sprayed	810	13·6	5·6
Removal at 8 weeks, sprayed	562	22·6	14·8
No removal, unsprayed	762	27·2	20·9
Necessary differences for significance { 5%	151	2·4	
Necessary differences for significance { 1%	209	3·3	

(c) Trial 3

Growing conditions were good until early March, after which further irrigation of the trial site was impracticable and dry weather did not allow the plants on which removal was carried out six weeks after first burst of squaring to mature a high percentage of the considerable form production obtained (Table 8). The same conditions prevented high production where removal was carried out at eight weeks. These results indicate that with severe loss of forms in mid-season (removal at six and eight weeks) followed by poor growing conditions plant recovery is not good.

The unsprayed treatment produced more forms than the no-removal/sprayed treatment, as could be expected; yield, however, was lower. More bolls were harvested from the unsprayed treatment, many being partly damaged, a higher percentage of mature bolls was unpickable (Table 9) and a higher percentage of fallen forms was damaged by insect attack (Table 7) than in the no-removal/sprayed treatment. These facts and observations prove that late

TABLE 8

Trial 3. Production of Fruit Forms

Treatment	Production per Plant		Date of Removal
	Total	From Time of Removal	
No removal, sprayed	27·1	27·1	—
Removal at 2 weeks, sprayed	46·6	30·3	Dec. 16
Removal at 4 weeks, sprayed	44·2	22·6	Dec. 30
Removal at 6 weeks, sprayed	65·2	31·5	Jan. 14
Removal at 8 weeks, sprayed	47·3	21·4	Jan. 28
No removal, unsprayed	33·4	33·4	—
Necessary differences for significance .. .. .. { 5%	8·6	6·3	
Necessary differences for significance .. .. .. { 1%	11·9	8·7	

attack by *Pectinophora scutigera* (Hold.) caused lower yields where no spray was applied. It is again demonstrated, as in Trial 2, that late-season pest attack can cause economic losses.

TABLE 9

Trial 3. Yields, Numbers of Plants and Mature Bolls

Treatment	Yield (lb/ac)	Plants per Plot	Mature Bolls		
			Pickable	Unpickable (%)	
				Trans. Mean	Equiv. Mean (%)
No removal, sprayed	1,980	80·5	582	7·6	1·8
Removal at 2 weeks, sprayed	1,980	78·2	612	3·3	0·3
Removal at 4 weeks, sprayed	1,639	80·5	558	6·6	1·3
Removal at 6 weeks, sprayed	998	77·2	377	7·8	1·8
Removal at 8 weeks, sprayed	608	80·8	298	13·5	5·4
No removal, unsprayed	1,668	79·0	631	14·6	6·3
Necessary differences for significance 5%	273	No sig.	89	3·4	
Necessary differences for significance 1%	377	diff.	123	4·7	

(d) Trial 4

Growing conditions were good until early March, after which dry conditions prevailed, and, as in Trial 3, despite high production of forms (Table 11) yields (Table 12) were low in plots where removal was carried out at six and eight weeks after the first burst of squaring. It is again demonstrated that recovery is poor after severe loss of forms during mid-season followed by adverse growing conditions. In addition, treatments where removals were made at six and eight weeks and the unsprayed treatment were severely damaged by *P. scutigera* late in the season.

TABLE 10

Trial 4. Total and Damaged Fallen Forms

Treatment	Mean from Time of Removal	Damaged Forms (%)	
		Trans. Mean	Equiv. Mean (%)
No removal, sprayed	463	19·9	11·6
Removal at 2 weeks, sprayed	554	23·4	15·8
Removal at 4 weeks, sprayed	612	27·0	20·6
Removal at 6 weeks, sprayed	914	26·0	19·1
Removal at 8 weeks, sprayed	502	36·6	35·6
No removal, unsprayed	637	33·8	33·8
Necessary differences for significance 5%	158	4·3	
Necessary differences for significance 1%	219	6·0	

TABLE 11

Trial 4. Production of Fruit Forms

Treatment	Production per Plant		Date of Removal
	Total	From Time of Removal	
No removal, sprayed	16·0	16·0	—
Removal at 2 weeks, sprayed	24·8	19·7	Feb. 4
Removal at 4 weeks, sprayed	36·4	22·7	Feb. 19
Removal at 6 weeks, sprayed	40·8	25·0	Mar. 4
Removal at 8 weeks, sprayed	31·0	15·6	Mar. 19
No removal, unsprayed	18·1	18·1	—
Necessary differences for significance 5%	9·2	5·3	
Necessary differences for significance 1%	12·8	7·3	

TABLE 12

Trial 4. Yields, Numbers of Plants and Mature Bolls

Treatment	Yield (lb/ac)	Plants per Plot	Mature Boll	
			Pickable	Total
No removal, sprayed	1,297	86	462	493
Removal at 2 weeks, sprayed	1,224	85	475	530
Removal at 4 weeks, sprayed	1,157	81	476	556
Removal at 6 weeks, sprayed	(345)	98	(180)	(258)
Removal at 8 weeks, sprayed	(78)	95	(56)	(129)
No removal, unsprayed	758	88	334	437
Necessary differences for significance 5%	162	No sig.	79	
Necessary differences for significance 1%	233	diff.	113	

V. GENERAL DISCUSSION AND CONCLUSIONS

In Central Queensland, loss of fruit forms during the month after the first burst of squaring does not affect yields.

Maturing of replacement forms following removals during the second month is dependent on the length of the season and growing conditions.

Eaton (1931) in the United States of America, McKinlay and Geering (1957) in East Africa and others obtained basically similar results.

In Central Queensland, length of season is not important except with December plantings in the Callide and Dawson Valleys, where removals during the second month may not allow sufficient time for crop maturity in some seasons.

Under good growing conditions replacement of forms will occur, and increased yield may follow removals. When poor early growth is followed by

good conditions, removals during the second month will not affect yields; poor conditions late in the season, however, will prevent plant recovery. Considerable risk, therefore, is associated with severe loss of fruit forms in rain-grown cotton at any stage later than one month after the first burst of squaring.

The effects of loss and damage among fruit forms late in the season is clearly demonstrated by the unusually severe *H. armigera* attack during March in Trial 2 and the incidence of *P. scutigera* during 1958-59.

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