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HELIOTHIS AS A PEST OF COTTON IN CENTRAL QUEENSLAND

By T. PASSLOW, M.Agr.Sc., Entomologist, Science Branch, Division of Plant Industry.

SUMMARY.

Over the 10-year period 1948–1957, 13 trials with modern insecticides against Heliothis armigera **(Hubn.) were conducted on both irrigated and rain-grown cotton in Central Queensland. Results from four of these trials show total yield increases after DDT applications which were successful in killing** Heliothis armigera; **the increase was economically significant in one instance only.**

During the 1955-56 season investigations were expanded to cover plant reaction to pest kills. Although goods kills of Heliothis and most other insects were obtained there was an increase in yields in the first pick but no differences among total yields. The killing of Heliothis caused the plants to hold larger percentages of early squares and bolls; later, however, fall from sprayed plants was sudden while that from unsprayed plants was gradual. Consequent replacement of squares and bolls was responsible for the levelling of total yields.

I. INTRODUCTION.

Heliothis armigera (Hubn.) has been considered a major pest of cotton in Central Queensland since the inception of the cotton-growing industry there.

One of the earliest recommendations on control in Queensland was that of Boyd (1908), who advocated growing maize or cowpeas as a trap crop in association with cotton. Ballard (1927) advised trap crops of maize and stated that calcium arsenate dust would stop an attack if two applications, a fortnight apart, were made when the crop was squaring. Currie (1928) advocated cultural measures, including planting as early as possible, as methods of escaping damage. Atherton (1932) stated that although Heliothis had been considered the most serious pest of cotton in the Callide Valley for some years it caused very little loss in 1931-32. He later reported (Atherton 1933) that bait trapping of Heliothis moths with several materials was of no value in controlling the insect in cotton. In 1935, Veitch considered that Heliothis in cotton could be neither successfully nor economically controlled with insecticides,

and recorded then (Veitch 1935) and again in 1938 (Veitch 1938) that maize trap crops were an advantage only if carefully handled. Sloan (1938) stated that maize trap crops had not been generally successful although the system had some advantages; in 1945 the same author (Sloan 1945) considered that migrating Heliothis larvae could be controlled either by baiting with Paris green or by spraying with lead arsenate. In 1951 (Officers of the Department of Agriculture and Stock 1951), the official recommendation was dusting or spraying with arsenate of lead when egg numbers on terminals rose above 7 per 25 terminals, in addition to cultural control. Passlow (1958) stated that in recent years many growers had used programme spraying, applying DDT at 0·2 per cent. in 25–50 gal. water per acre two weeks after germination and at the first major burst of squaring, with a third application three weeks later; some growers used DDT when egg numbers exceeded 15 per 100 terminals.

Field trials concerned with insecticide treatments were conducted annually from 1948 to 1957. All, except one during 1955-56 and one during 1956-57 in the Rockhampton district, were carried out on the Biloela Regional Experiment Station. The trials, using the variety Miller 41S, were designed to give insecticide (principally DDT) cover during major square and early boll development and the period of maximum Heliothis activity, and to ascertain the economic value of this protection.

II. MATERIALS.

The following insecticides were used:—

Aldrin.—An emulsifiable preparation containing 40 per cent. w/v active ingredient.

BHC.—A miscible oil preparation containing 6·5 per cent. w/v active ingredient.

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

A dispersible china clay powder containing 50 per cent. *p.p'* isomer.

A kaolin dust containing 2·0 per cent. *p.p'* isomer.

Dieldrin.—An emulsifiable preparation containing 15 per cent. w/v active ingredient.

Endrin.—An emulsifiable preparation containing 20 per cent. w/v active ingredient.

Guthion.—An emulsifiable preparation containing 18 per cent. w/v active ingredient.

*Parathion E*605.—An emulsifiable preparation containing 25 per cent. w/v active ingredient.

III. METHODS.

Plot size was never less than 6 rows of cotton (3 ft. 6 in. inter-row spacing) each 1 chain long.

Heliothis egg counts were made each season. Prior to the 1955-56 season they were made on 100 terminals attractive to ovipositing moths selected at random on traverses of the trial area, and in later trials on terminals of 30 plants per plot selected at random in six groups of five. A terminal was taken as that part of the plant from the growing point to the fifth leaf from the top.

Insecticides were applied either by knapsack sprays and dusters or by mechanical boom sprays and dusters.

Observations on attacks by insects other than Heliothis were made.

Of the 13 trials, six were irrigated, and all were harvested by hand in one, two or three picks. Plot yields have been converted to the economic unit of pounds of seed cotton per acre.

During the 1955-56 season and at Rockhampton in 1956-57 some attention was given to plant behaviour in relation to pest control; fruit production assessments and insect damage counts were made. At Biloela (1955-56) four plants, at Rockhampton (1955-56) two groups of three plants, and at Rockhampton (1956-57) five plants in observation rows near the datum or yield rows in each plot, were selected and removed each week from the commencement of squaring until harvest. All squares and bolls were counted and the numbers damaged by insects recorded. Also, in 1955-56 all fruits fallen from these plants during the preceding week were collected and counted and the numbers damaged by insects were recorded. In 1956-57 all fruits fallen in two inter-row spaces each 20 ft. long were collected each week and treated as above.

Trial layout, details of treatments with insecticide dosage expressed as percentage of active ingredient and gallons of spray or pounds of dust per acre, and other relevant information, are given with the results of each trial.

IV. RESULTS.

(1) Trial 1. 1948-49. 2 x 10 Paired Plots. Irrigated.

The crop was planted on Oct. 26 and sprays were applied on Nov. 5 (seedling spray), Nov. 26, Dec. 16 and Jan. 24 at approximately 20, 35, 35 and 35 gal. per acre respectively. Light Heliothis infestations were present at spraying times and other pests were in negligible populations throughout the season. Harvesting was on Mar. 25–31 and July 2–7. The results are given in Table 1.

Table 1.

TRIAL 1. YIELDS.

Treatment.	1st Pick. (Lb./ac.).	2nd Pick. (Lb./ac.).	Total. (Lb./ac.).
DDT emulsion 0·4%	830	377	1,207
Check	687	435	1,122

Despite the small numbers of pests, DDT sprays increased first-pick yield (by 20·8 per cent.), but total yield was not increased.

(2) Trial 2. 1949-50. 4 x 5 Randomised Block. Irrigated.

The crop was planted on Oct. 18 and spray applications were made on Dec. 14 and Jan. 9 at 36 and 48 gal. per acre respectively. Maximum egg counts, on Dec. 14, Dec. 20, Jan. 3 and Jan. 12, were 16, 9, 6 and 7 per 100 terminals. Yields were obtained in three picks, on Mar. 20–23, May 11–15 and Aug. 2, and are given in Table 2.

Table 2.

TRIAL 2. YIELDS.

Treatment.	1st Pick. (Lb./ac.).	2nd Pick. (Lb./ac.).	3rd Pick. (Lb./ac.).	Total. (Lb./ac.).
DDT emulsion 0·4%	1,094	221	399	1,714
Parathion 0·015%	954	220	473	1,647
DDT emulsion 0·2% plus Parathion 0·0075%	1,048	230	320	1,598
Check	648	238	587	1,473
Necessary differences for significance .. 5%	143	49	119	125
Necessary differences for significance .. 1%	193	66	161	168

Although the incidence of pests was low, sprays gave significant increases in the first pick and in the total yields. DDT increased yields by 68·8 per cent. on the first pick and by 16·4 per cent. on the total yield.

(3) Trial 3. 1950-51. 4 x 10 Randomised Block. Irrigated.

The crop was planted on Oct. 13. Heliothis egg counts were low, maximum numbers being 9 per 100 terminals prior to the first spray and 17 per 100 terminals on Feb. 14. Treatments were the same as in Trial 2 and were applied on Dec. 19, Jan. 1 and Feb. 15 at 27, 45 and 40 gal. per acre respectively. Harvesting was on Mar. 19-28 and May 29-June 4. No significant yield differences were obtained. Mean yield was 1,240 lb. per acre.

(4) Trial 4. 1950-51. 2 x 12 Paired Plots. Not Irrigated.

The crop was planted on Oct. 13. Peak Heliothis egg counts of 6 and 28 per 100 terminals were recorded on Dec. 19 and Feb. 21. A moderate infestation of jassids (*Austroasca terrae-reginae* (Paoli) and *A. viridigrisea* (Paoli)) occurred prior to the second application. DDT as a 0·4 per cent. dispersible powder was applied on Dec. 19 and Jan. 30 at 20 and 40 gal. per acre and as a 2·0 per cent. dust on Feb. 16 at 24 lb. per acre.

Harvesting was on Mar. 30 and June 5–22. Yields are given in Table 3.

Table 3.

TRIAL 4. YIELDS.

Treatment.	1st Pick. (Lb./ac.).	2nd Pick. (Lb./ac.).	Total. (Lb./ac.).
DDT	602	628	1,230
Check	531	575	1,106

DDT significantly increased yields—by 13·4 per cent. on the first pick and by 11·2 per cent. on the total.

(5) Trial 5. 1951-52. 5 x 5 Randomised Block. Irrigated.

The crop was planted on Oct. 17. Peak Heliothis egg counts were on Dec. 7, 14 and 21 and Feb. 8 and 10, when 100, 41, 83, 8 and 10 eggs per 100 terminals respectively were recorded. Treatments were applied on Nov. 27, Dec. 12 and 22 and Feb. 5 at 18, 18, 30 and 40 gal. per acre respectively. Harvesting was on Apr. 8–May 5 and July 9. Yields are given in Table 4.

Table 4.

TRIAL 5. YIELDS.

Treatment.		1st Pick. (Lb./ac.).	2nd Pick. (Lb./ac.).	Total. (Lb./ac.).
DDT emulsion 0·4%		1,459	89	1,548
BHC 0·035%		1,257	142	1,399
Parathion 0·015%		1,251	136	1,387
Dieldrin 0·05%		1,226	153	1,379
Check		1,256	131	1,387
Necessary differences for significance	5%	147	40	120
	1%	202	55	166

DDT significantly increased yields—by 16·2 per cent. on the first pick and by 11·6 per cent. on the total yield. Dieldrin was used at a comparatively low application rate.

(6) Trial 6. 1952-53. 5 x 4 Randomised Block. Not Irrigated.

This crop was planted on Oct. 11. Peak Heliothis egg counts of 70, 12 and 17 per 100 terminals were recorded on Nov. 22 and Dec. 15 and 30. DDT was applied on Dec. 4 and 19 and Jan. 5 and 20, at 20 and 40 gal. per acre respectively. Harvesting was on Mar. 25–Apr. 7 and June 1–5. Yields are given in Table 5.

Table 5.

TRIAL 6. YIELDS.

Treatment.	1st Pick. (Lb./ac.).	2nd Pick. (Lb./ac.).	Total. (Lb./ac.).
DDT emulsion 0·13%	753	683	1,436
DDT emulsion 0·27%	851	663	1,614
DDT emulsion 0·40%	917	461	1,378
DDT emulsion 0·53%	878	443	1,321
Check	563	565	1,128

Yield increases to 63·0 per cent. occurred at the first pick but there were no differences among total yields. The non-uniformity of second-pick yields was related to more favourable soil moisture in some plots for second-pick growth.

(7) Trial 7. 1952-53. 5 x 4 Randomised Block. Irrigated.

The crop was planted on Oct. 15. Peak Heliothis egg counts of 76, 114 and 63 per 100 terminals were recorded on Dec. 4, 14 and 30. The same treatments as in Trial 6 were applied on Dec. 5 and 19 and Jan. 5 at 25, 40 and 40 gal. per acre. Harvesting was on May 1 and June 10 and no significant differences were obtained. The mean yield was 1,075 lb. per acre.

(8) Trial 8. 1953-54. 5 x 5 Latin Square. Irrigated.

The crop was planted on Oct. 31. Peak Heliothis egg counts of 36, 55, 18 and 70 per 100 terminals were recorded on Dec. 13 and 21 and Jan. 4 and 12. Treatments were DDT emulsion 0·1 per cent. and 0·05 per cent., DDT dust 2·0 per cent. and 1·0 per cent., and a check. Applications were made on Nov. 25, Dec. 15 and Jan. 6, the sprays being used at 25, 100 and 100 gal. per acre and the dusts at 25, 50 and 50 lb. per acre respectively. Harvesting was on Mar. 17–19, May 27–28 and July 16–19. No significant differences were obtained. The mean yield was 1,387 lb. per acre.

(9) Trial 9. 1954-55. 5 x 4 Randomised Block. Not Irrigated.

The crop was planted on Oct. 9. Peak Heliothis egg counts of 8, 61, 13 and 10 per 100 terminals were recorded on Dec. 22 and 30 and Jan. 7 and 13.

Two DDT emulsion treatments, applied through different types of boom sprays, and two DDT dust treatments applied by power duster, one with a trailing nylon sheet, were used. Applications were made on Dec. 2 and 24 at 1 lb. active ingredient in 15 gal. per acre and 50 lb. per acre respectively. Harvest was on Mar. 16–25 and July 13–18. No significant differences were obtained. The mean yield was 594 lb. per acre.

(10) Trial 10. 1955–56. 6 x 4 Randomised Block. Not Irrigated.

The crop was planted on Nov. 11. Heliothis egg counts were low except on Jan. 10 and 16 and Feb. 6, when 37·2, 2·5 and 6·1 per 100 terminals were recorded. Treatments were applied on Jan. 9 and 24, Feb. 7 and 22 and Apr. 7 at 60, 90, 90, 70 and 60 gal. per acre respectively. The last application was for attempted control of *Pectinophora scutigera* (Hold.), which was active during late March and April.

Each week the percentages of damaged and total number of squares and bolls held by the plants and the percentages damaged and numbers of fallen squares and bolls were recorded. These data are summarised in Table 6 for the whole production period (Jan. 16–May 15), and for fallen for the period of some insecticide cover (Jan. 16–Apr. 24). Prior to analyses of the percentages of squares and bolls damaged, the inverse sine transformation was used. Harvest was on Apr. 9–13 and May 31. Yields are given in Table 7.

Table 6.

TRIAL 10. PERCENTAGES DAMAGED AND TOTAL NUMBERS OF SQUARES AND BOLLS.

Treatment.	Percentage of Damaged Squares and Bolls.					No. of Fallen Squares and Bolls.	
	In Weekly Examination on Plants.	In Fallen from Jan. 16 to Apr. 24.		In Fallen during Whole Period.		From Jan. 16 to Apr. 24.	During Whole Period.
		Trans. Mean.	Equiv. Mean %.	Trans. Mean.	Equiv. Mean %.		
DDT emulsion 0·1%	4·8	21·42	13·3	22·00	14·0	160·8	187·0
DDT emulsion 0·1% plus White oil 1 : 100 (wetting agent)	4·2	18·20	9·8	18·02	9·6	142·5	163·8
Endrin 0·05% ..	3·7	15·95	7·6	16·78	8·3	173·2	192·0
Dieldrin 0·1% ..	5·7	22·18	14·2	22·50	14·6	160·5	170·5
Aldrin 0·05% ..	8·6	24·32	17·0	24·75	17·5	160·0	171·0
Check	7·8	25·38	18·4	25·68	18·8	189·0	207·0
Necessary differences for significance 5%	..	4·05	..	3·26	..	56·0	52·0
Necessary differences for significance 1%	..	5·60	..	4·51	..	77·5	71·9

Table 7.

TRIAL 10. YIELDS.

Treatment.	1st Pick. (Lb./ac.).	2nd Pick. (Lb./ac.).	Total. (Lb./ac.).
DDT emulsion 0·1%	1,329	640	1,969
DDT emulsion 0·1% plus White oil 1 : 100 (wetting agent) ..	1,138	755	1,893
Endrin 0·05%	1,510	795	2,305
Dieldrin 0·1%	1,205	966	2,171
Aldrin 0·05	1,138	778	1,916
Check	1,009	952	1,961
Necessary differences for significance 5%	202	..	229
Necessary differences for significance 1%	281	..	322

Endrin and DDT gave significantly increased first-pick yields (DDT by 31·7 per cent), but only endrin increased total yields; this increase was due to control of the looper *Anomis flava* Fabr. and other leaf pests. Treatments had no significant effect on the numbers of squares and bolls lost by the plants, but in both the period of some insecticide cover and the whole examination period significantly fewer fallen squares and bolls were damaged by insects.

(11) Trial 11. 1955–56. 6 x 4 Randomised Block. Not Irrigated. Rockhampton.

The crop was planted on Nov. 4. Helothis egg counts were low, two minor peaks of 9·7 and 12·6 per 100 terminals occurring on Dec. 12 and Jan. 3 respectively. Treatments were applied on Jan. 11 and 25 and Feb. 15 and 29 at 50, 63, 63, and 84 gal. per acre respectively. As in Trial 10, each week the percentages of damaged and total numbers of squares and bolls held by the plants and the percentages damaged and numbers of fallen squares and bolls were recorded. These data are summarised in Table 8 for the whole production period (Jan. 19–June 13), and for fallen for the period of some insecticide cover (Jan. 19–Mar. 7). Prior to analyses of the percentages of squares and bolls damaged, the inverse sine transformation was used. Harvest was on Apr. 23–May 15 and June 18–21. Yields are given in Table 9.

The significant yield increases obtained in endrin and to a lesser extent in DDT plots were due to control of *Anomis flava,* which caused extensive leaf damage in check areas. Treatments had no significant effect on the numbers of fruits lost by the plants but significantly fewer fallen fruits were damaged by insects during the period of insecticide cover in DDT and endrin plots.

(12) Trial 12. 1956–57. 4 x 6 Randomised Block. Not Irrigated.

The crop was planted on Nov. 9. Heliothis egg numbers did not exceed 2·2 per 100 terminals except on Jan. 9, when 15 per 100 were recorded.

Table 8.

TRIAL 11. PERCENTAGES DAMAGED AND TOTAL NUMBERS OF SQUARES AND BOLLS.

Treatment.	Percentage of Damaged Squares and Bolls.					No. of Fallen Squares and Bolls.	
	In Weekly Examination on Plants.	In Fallen from Jan. 19 to Mar. 7.		In Fallen during Whole Period.		From Jan. 19 to Mar. 7.	During Whole Period.
		Trans. Mean.	Equiv. Mean %.	Trans. Mean.	Equiv. Mean %.		
DDT emulsion 0·1%	4·9	32·0	28·0	28·2	22·4	109·0	91·0
DDT emulsion 0·1% plus White oil 1 : 100 (wetting agent)	4·9	29·4	24·1	28·0	22·0	96·0	89·5
Endrin 0·05% ..	4·8	30·2	25·3	24·6	17·4	90·0	77·8
Dieldrin 0·1% ..	5·6	40·6	42·4	31·0	26·4	79·2	85·2
Aldrin 0·05% ..	6·2	38·3	38·4	33·4	30·2	107·5	90·0
Check	5·9	42·4	45·5	32·8	29·4	80·8	83·2
Necessary differences for significance 5%	..	9·8	..	8·3	..	39·4	21·6
Necessary differences for significance 1%	..	13·5	..	11·4	..	54·4	29·9

Table 9.

TRIAL 11. YIELDS.

Treatment.	1st Pick. (Lb./ac.).	2nd Pick. (Lb./ac.).	Total. (Lb./ac.).
DDT emulsion 0·1%	536·8	230·3	767·1
DDT emulsion 0·1% plus White oil 1 : 100 (wetting agent) ..	431·9	286·6	718·5
Endrin 0·05%	573·7	269·7	843·4
Dieldrin 0·1%	391·6	220·3	611·9
Aldrin 0·05%	444·7	230·3	675·0
Check	261·8	272·5	534·3
Necessary differences for significance 5%	136·1	..	232·3
Necessary differences for significance 1%	187·9	..	321·5

Four applications of the treatments DDT emulsion 0·1 per cent., endrin 0·05 per cent. and guthion 0·1 per cent. were given at 30 gal. per acre on Jan. 9 and 23 and Feb. 6 and 20. Harvesting was on Apr. 12–14; no significant differences were obtained. The mean yield was 636 lb. per acre.

(13) Trial 13. 1956–57. 4 x 6 Randomised Block. Not Irrigated. Rockhampton.

The crop was planted on Nov. 16. Heliothis egg counts were low, maximum records being 7·8 and 16·1 per 100 terminals on Feb. 5 and 26 respectively. Treatments were applied on Jan. 30, Feb. 13 and 28 and Mar. 13 at 112, 118, 114, and 130 gal. per acre respectively.

Table 10.

TRIAL 13. PRODUCTION AND NUMBERS OF DAMAGED AND TOTAL FALLEN SQUARES AND BOLLS.

Treatment.	Square and Boll Production from Five Plants per Plot per Week.			Numbers of Damaged Fallen Squares and Bolls.			Total Numbers of Fallen Squares and Bolls.		
	Until Feb. 26.	Until 1st Pick.	Damaged until 1st Pick.	Until Feb. 26.		Until 2nd Pick.	Until Feb. 26.		Until 2nd Pick.
				Means.	Equiv. Mean Nos.	Mean Nos.	Means.	Equiv. Mean Nos.	Mean Nos.
DDT emulsion 0·1%	26·5	44·9	12·7	3·80	14·4	73·8	5·16	26·6	251·9
Endrin 0·05% ..	36·3	48·9	18·4	4·64	21·5	108·7	5·43	29·5	238·1
Guthion 0·1% ..	24·4	43·6	19·0	5·65	31·9	117·9	6·59	43·4	255·2
Check	35·2	64·8	25·5	7·69	59·1	145·9	8·25	68·1	339·2
Necessary differences for significance 5%	10·6	15·3	9·8	2·34	..	62·1	2·23	..	99·5
Necessary differences for significance 1%	14·7	21·2	13·5	3·23	..	85·9	3·08	..	137·5

As in 1955–56, each week the percentages damaged and total numbers of squares and bolls held by the plants and the numbers damaged and total numbers of fallen squares and bolls were recorded. The production of

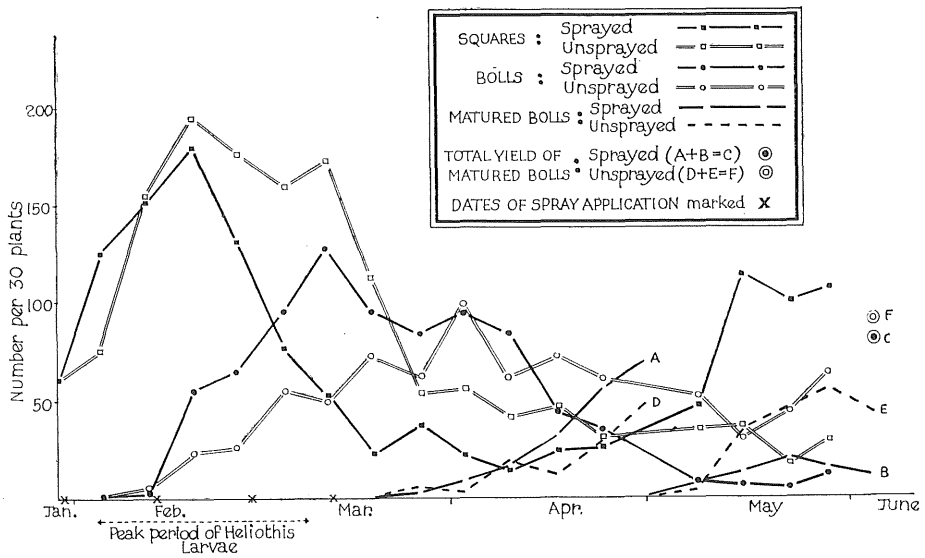

Fig. 1.

Plant Behaviour and Yields. Trial 13, 1956-57.

squares and bolls each week has been calculated and these and other data are summarised in Table 10, the square root transformation being used where necessary. Production figures and data of fallen squares and bolls are presented for the period Jan. 29 to Feb. 26, during which major square and boll loss occurred, and for the whole period Jan. 29 to May 28. The numbers of squares and bolls on the plants each week are given in Fig. 1. Harvest was on May 1–3 and June 4. The yields are given in Table 11.

Table 11.

TRIAL 13. YIELDS.

Treatment.	1st Pick. (Lb./ac.).	2nd Pick. (Lb./ac.).	Total. (Lb./ac.).
DDT emulsion 0·1%	392·7	41·6	434·3
Endrin 0·05	328·5	78·5	407·0
Guthion 0·1%	271·7	94·5	366·2
Check	224·0	192·7	416·7
Necessary differences for significance 5%	80·2	..	101·9
Necessary differences for significance 1%	111·0	..	140·9

This trial was conducted under very dry conditions. Although DDT treated plots gave significantly increased first-pick yields the high numbers of early squares were not produced as in other trials carried out under better field conditions.

V. DISCUSSION.

Early workers with cotton in Central Queensland assumed that Heliothis was a serious pest, and to assure production attempted to protect the crops during early squaring. Several cultural methods were suggested, and insect applications followed the American pattern (e.g. Gaines 1939), using Heliothis egg counts as a guide to spraying. Most of these investigations were limited to observations.

In this paper, trials with modern insecticides over a 10-year period are recorded. Of the 13 conducted in both irrigated and rain-grown crops, results from four show total yield increases after DDT applications: the increase was economically significant only in Trial 2. In this trial the use of parathion, which is not particularly efficacious in killing Heliothis, was also responsible for increased total yields. Furthermore, in trials where DDT and materials of only moderate value against Heliothis were used there were no significant differences among total yields. Until the 1955–56 season, entomological observations concerned with these trials were limited to Heliothis egg counts. In that season more detailed investigations, also covering plant behaviour, were commenced; and although good kills of Heliothis and most other insects were obtained, there was an increase in yields in the first pick

but no differences among total yields. The killing of Heliothis caused the plants to hold larger percentages of early squares and bolls; later, however, fall from sprayed plants was sudden while that from unsprayed plants was gradual. Consequent replacement of squares and bolls was responsible for the levelling of total yields (See Fig. 1 and Passlow 1958). Current entomological research on cotton pests is following the approach as used during the 1955–56 season. The main interest, however, is not in killing insects, for which purpose satisfactory methods are readily available, but rather in correlating these kills with yields from crops grown under differing agronomic conditions.

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