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STUDIES ON CODLING MOTH CONTROL IN THE STANTHORPE DISTRICT, QUEENSLAND

By M. BENGSTON, M.Sc.*

SUMMARY

During the 1958-59 to 1962-63 seasons, nine trials were conducted to determine the value of new insecticides for the control of *Cydia pomonella* (L.) in apple orchards of the Stanthorpe district.

The important materials under test were azinphos-ethyl, azinphos-methyl, carbaryl, carbophenothion, DDT, dioxathion, ethion, lead arsenate, Mesurol and phosphamidon. Treatments were applied according to predetermined programmes for each season. Other sprays, either alone or in combination with the test materials, were used to control diseases and pests other than codling moth.

DDT exercised satisfactory control for codling moth in the 1958-59 trial but there was a marked reduction in efficacy in subsequent trials. Azinphos-ethyl, azinphos-methyl, carbaryl and Mesurol were the better treatments in later trials and have been recommended for codling moth control in the Stanthorpe district.

I. INTRODUCTION

In a review of the codling moth (*Cydia pomonella* (L.)) as a pest of apples in the Stanthorpe district, May and Bengston (1959) detailed orchard control trials for the 1949-50 and 1956-57 seasons. From this work it was concluded that none of the newer materials tested gave better results than DDT and that no alterations to the codling moth spray programme of May and Bengtson (1955) were required. A marked reduction in the degree of control achieved by DDT became apparent in subsequent years and indicated that further testing of new materials was warranted. This work was commenced in the 1958–59 season and has been continued in each season.

* Research Entomologist, Queensland Department of Primary Industries

II. MATERIALS

The materials used and the percentages of active constituents in prepared sprays were as follows.

A. *For Codling Moth Control*

Azinphos-ethyl.—A dispersible powder containing 25 per cent. w/w active constituent: used at 0·05 per cent.

An emulsifiable concentrate containing 40 per cent. w/v active constituent: 0·05 per cent.

Azinphos-methyl.—A dispersible powder containing 25 per cent. w/w active constituent: 0·05 per cent.

Carbaryl.—A dispersible powder containing 50 per cent. w/w active constituent: 0·1 per cent.

Carbophenothion.—A dispersible powder containing 30 per cent. w/w active constituent: 0·03 per cent.

DDT.—An emulsion concentrate containing 25 per cent. w/v active constituent: 0·1 per cent.

Dioxathion.—An emulsifiable concentration containing 50 per cent. w/v active constituent: 0·06 per cent.

Ethion.—An emulsifiable concentrate containing 50 per cent. w/v active constituent: 0·05 per cent.

Lead arsenate.—A powder containing 31 per cent. As_2O_5 as lead arsenate, and 1 per cent. wetting agent: 3 lb per 100 gal with *Hydrated lime.*—Finely divided calcium hydroxide: 3 lb per 100 gal.

"Mesurol".—Dispersible powders containing 25 per cent. or 50 per cent. w/w 3,5-dimethyl-4-mercaptophenyl-N-methylcarbamate: 0·1 and 0·05 per cent.

Phosphamidon.—A concentrate containing 50 per cent. w/v active constitutent: 0·04 per cent.

B. *For Other Purposes*

Captan[1].—A dispersible powder containing 50 per cent. w/w active constituent: 0·1 per cent.

DDD (TDE)[2].—An emulsion concentrate containing 30 per cent. w/v active constituent: 0·1 per cent.

Dicofol[3].—An emulsifiable concentrate containing 20 per cent. w/v active constituent: 0·05 per cent.

Dodine acetate[1].—A dispersible powder containing 65 per cent. w/w constituent: 0·1 per cent.

"Glyodin"[1].—A concentrate containing 21 per cent. 2-heptadecyl glyoxalidine as acetate: 0·026 per cent.

[1] Fungicides. [2] For light-brown apple moth. [3] A miticide.

III. METHODS

Randomized blocks with single-tree plots were used in all experiments. Treatments were applied at a pressure of 200–250 lb/sq. in., using a small power spray with a hand-operated lance. Complete tree cover was aimed at. Harvested and windfall fruit from plot trees were examined for larval damage. A fruit was recorded as sound if there were no signs of codling moth damage. Once damage was evident the fruit was classified as "stung". In some trials the stung fruit were subdivided into "blind stings", if larvae failed to develop, and "wormy", if larvae developed to maturity. The materials and trial programmes were determined by the necessity for control of other members of the apple pest complex. Layouts, spray combinations, detailed programmes, treatment application dates and other relevant data are given with the results of each trial.

IV. RESULTS

(a) Trial 1, 1958-59

Trial 1 consisted of a 4 x 6 randomized block on the variety Granny Smith. Treatments (see Table 1) were applied on November 14, December 4, January 6 and February 4. Results for the entire crop are given in Table 1.

TABLE 1

FRUIT DAMAGE, TRIAL 1, 1958–59

Treatment	Percentage Stung Fruit		Percentage Blind Stings/Total Stings	
	Transformed Mean*	Equivalent Mean	Transformed Mean*	Equivalent Mean
DDT 0·1%	17·6	9·1	42·3	45
Azinphos-methyl 0·1%	15·6	7·3	60·1	75
Carbophenothion 0·03% ..	24·2	16·8	44·8	50
Untreated	40·2	41·7	28·4	23
Necessary differences for significance 5%	4·8		12·0	
Necessary differences for significance 1%	6·6		16·7	

* Inverse sine transformation

Azinphos-methyl and DDT were significantly better than carbophenothion in reducing codling moth damage, although carbophenothion did exercise a degree of control. There was an indication from the percentages of blind stings that azinphos-methyl was better than DDT. The performance of both of these materials was considered satisfactory under the conditions prevailing in this trial.

(b) Trials 2 and 3, 1959–60

Reports from certain orchards during the 1958–59 season indicated that the DDT programme was not giving satisfactory control. Accordingly two trials were carried out in 1959–60, each in an area where the difficulties had been experienced. Each trial was a 6 x 4 randomized block on the variety Granny Smith. Treatments (see Table 2) were applied on the following dates:

Trial 2: October 23, November 6 and 24, December 15, January 7 and 26.

Trial 3: October 20, November 6 and 23, December 14, January 4 and 25. Other treatments were included for the control of light-brown apple moth (*Epiphyas postvittana* (Walk.)), and for mites, chiefly *Tetranychus telarius* (L.). These were DDD applied on November 23–24 and January 25–26 and dicofol on November 23–24 and January 4 and 7. They were applied in combination with the respective trial treatments and were also applied to the untreated trees.

TABLE 2

PERCENTAGES OF SOUND AND WORMY FRUIT, TRIALS 2 AND 3, 1959–60

Treatment	Trial 2		Trial 3			
	Windfall Fruit		Entire Crop			
	Percentage Sound Fruit		Percentage Sound Fruit		Percentage Wormy Fruit	
	Transformed Mean*	Equivalent Mean	Transformed Mean*	Equivalent Mean	Transformed Mean*	Equivalent Mean
DDT 0·1%	18·4	9·9	23·4	15·8	64·1	81·0
Azinphos-methyl 0·05% ..	58·2	72·2	54·5	66·3	32·0	28·1
Dioxathion 0·06% ..	50·3	59·1	56·4	69·4	24·4	17·1
Ethion 0·05%	39·0	39·5	54·1	65·7	24·6	17·3
Carbaryl 0·1%	55·7	68·2	54·7	66·6	29·0	23·6
Untreated	20·4	12·2	15·4	7·0	72·8	91·3
Necessary differences for significance 5%	8·3		10·1		11·0	
Necessary differences for significance 1%	11·5		14·0		15·2	

* Inverse sine transformation

Fruit from Trial 2 was harvested in error by the orchardist and only windfalls were available for examination. Trial 3 was harvested on April 22. Results of each are given in Table 2.

From these results DDT was not significantly better than no treatment. Azinphos-methyl, carbaryl and dioxathion were better than ethion in Trial 2, but these four treatments were closely comparable in Trial 3.

(c) Trials 4 and 5, 1959–60

Trials 4 and 5 were undertaken to assess the efficacy of composite spray programmes against the entire apple pest complex. Each comprised a 7 x 4 randomized block, Trial 4 being on the variety Granny Smith and Trial 5 on the variety Delicious.

The programmes used in each trial are given in Table 3. Treatments were applied on the following dates:

Trial 4: October 22, November 7 and 24, December 16, January 7 and 26.

Trial 5: October 26, November 6 and 23, December 16, January 8 and 27.

Programme A included lead arsenate plus lime as the calyx spray. DDD and dicofol were added to some programmes (see Table 3).

TABLE 3

SPRAY PROGRAMMES USED IN TRIALS 4 AND 5, 1959–60

Programme	Time of Application					
	Calyx	Cover Spray				
		1	2	3	4	5
A	Lead arsenate Hydrated lime	DDT	DDT DDD Dicofol	DDT	DDT Dicofol	DDT DDD
B	Azinphos-methyl	Azinphos-methyl	Azinphos-methyl	Azinphos-methyl	Azinphos-methyl	Azinphos-methyl
C	DDT	Azinphos-methyl	DDT	DDT	Azinphos-methyl	DDT
D	Ethion	Ethion	Ethion DDD	Ethion	Ethion	Ethion DDD
E	Dioxathion	Dioxathion	Dioxathion DDD	Dioxathion	Dioxathion	Dioxathion DDD
F	Carbaryl	Carbaryl	Carbaryl Dicofol	Carbaryl	Carbaryl Dicofol	Carbaryl
G	Untreated	Untreated	Untreated	Untreated	Untreated	Untreated

Trial 4 was harvested during the period from May 3 to 13 and Trial 5 on March 23 and 24.

Results from Trials 4 and 5 are given in Table 4. Codling moth infestation was negligible in Trial 5.

TABLE 4

PERCENTAGE OF STUNG FRUIT (TRIAL 4) AND NUMBER OF FRUIT (TRIAL 5), 1959–60

Programmes (with important materials)	Trial 4		Trial 5
	Percentage Stung Fruit		Number of Fruit
	Transformed Mean*	Equivalent Mean	
A DDT and DDD	16·0	7·6	2,198
B Azinphos-methyl	9·9	3·0	1,999
C DDT and azinphos-methyl ..	11·6	4·0	1,566
D Ethion and DDD	8·0	1·9	1,890
E Dioxathion and DDD	8·3	2·1	1,521
F Carbaryl	8·5	2·2	437
G Untreated	36·2	35·0	1,925
Necessary differences for significance 5%	8·0		No analyses carried out
Necessary differences for significance 1%	10·9		No analyses carried out

* Inverse since transformation

In Trial 4 all treatments were significantly better than no treatment and there was a trend for programmes which included DDT to be less efficient than the other programmes. As reflected in counts of number of fruit per treatment in Trial 5, carbaryl caused a heavy fruit shed on the variety Delicious. This treatment also caused severe fruit russet. The variety Granny Smith in Trial 4 was unaffected.

(d) Trials 6 and 7, 1960–61

These two trials were comprised of 5 x 5 randomized blocks, similar though not identical. Trial 6 was on the variety Granny Smith and Trial 7 on the variety Dunns. Treatments (see Table 5) were applied on the following dates: October 13 and 27, November 19, January 4 and 25, February 20. The dispersible powder formulation of azinphos-ethyl was used for the first three applications and the emulsifiable concentrate for the remainder. DDD and dicofol, where used, were in combination with the respective treatments and also were applied to the untreated trees on November 19 and January 25. Dodine acetate was applied as a separate spray to all trees on November 18 and 30 and February 14.

Harvesting was carried out over the period February 1 to May 5 in Trial 6 and from March 25 to April 25 in Trial 7. Results are given in Table 5.

TABLE 5

PERCENTAGES OF SOUND AND WORMY FRUIT, TRIALS 6 AND 7, 1960–61

Treatment	Trial 6						Trial 7					
	Percentage Sound Fruit		Percentage Sound Fruit (excluding treatments A and F)		Percentage Wormy Fruit/ Total Stings		Percentage Sound Fruit		Percentage Sound Fruit (excluding treatments A and F)		Percentage Wormy Fruit/ Total Stings	
	Transformed Mean*	Equivalent Mean	Transformed Mean*	Equivalent Mean	Transformed Mean*	Equivalent Mean	Transformed Mean*	Equivalent Mean	Transformed Mean*	Equivalent Mean	Transformed Mean*	Equivalent Mean
A DDT 0.1%	51·84	61·8	**	**	75·34	93·6	38·78	39·2	**	**	77·76	95·5
B Dioxathion 0.06%	75·16	93·4	75·16	93·4	35·06	33·0	70·64	89·0	70·64	89·0	56·04	68·8
C Azinphos-methyl 0.05% ..	79·40	96·6	79·40	96·6	38·20	38·2	80·08	97·0	80·08	97·0	50·28	59·2
D Azinphos-ethyl 0.05%	78·40	96·0	78·40	96·0	33·74	30·8						
E Azinphos-methyl 0.05% plus Glyodin							74·28	92·7	74·28	92·7	47·72	54·7
F Untreated	40·32	41·9	**	**	78·12	95·8	24·78	17·6	**	**	84·48	99·1
Necessary differences for significance 5%	10·78		3·18		8·76		7·29		4·64		8·37	
Necessary differences for significance 1%	14·85		4·63		12·08		10·05		6·75		11·53	

* Inverse sine transformation

** Mean excluded from analyses

Azinphos-methyl and azinphos-ethyl were better than dioxathion, which in turn was better than DDT. There was an indication that the addition of Glyodin reduced the efficacy of azinphos-methyl.

(e) Trial 8, 1961–62

Trial 8 comprised a 5 x 4 randomized block on the variety Granny Smith. Treatments (see Table 6) were applied on the following dates: October 20, November 2 and 22, December 20, January 17 and February 19. Dodine acetate was applied as a separate spray to all trees on October 21, November 3, December 1 and 27, January 18 and March 12.

Harvesting was carried out from April 10 to 12. Results are given in Table 6.

TABLE 6

PERCENTAGES OF SOUND FRUIT (ENTIRE CROP), TRIAL 8, 1961–62

Treatment	Percentage Sound Fruit	
	Transformed Mean	Equivalent Mean*
Azinphos-methyl 0·05% ..	1·52	99·78
Azinphos-methyl 0·05% plus Glyodin 2 pt/100 gal	1·48	99·23
Azinphos-ethyl 0·05%	1·49	99·29
Mesurol 0·1%	1·52	99·75
Untreated	1·35	95·05
Necessary differences for significance 5%	0·12	
Necessary differences for significance 1%	0·17	

* Inverse sine transformation

All treatments were better than no treatment but there were no significant differences between the treatments. Fruit from trees treated with azinphos-ethyl emulsion was "ring-marked" (Figure 1).

(f) Trial 9, 1962–63

Trial 9 comprised a 5 x 5 randomized block on the variety Granny Smith. Treatments (see Table 7) were applied on the following dates: October 18, November 5 and 26, and January 14.

Captan was applied in combination with the respective treatments and was also applied to the untreated trees on each occasion. DDD 0·1 per cent. was applied in combination with the phosphamidon treatment on November 22 and January 14.

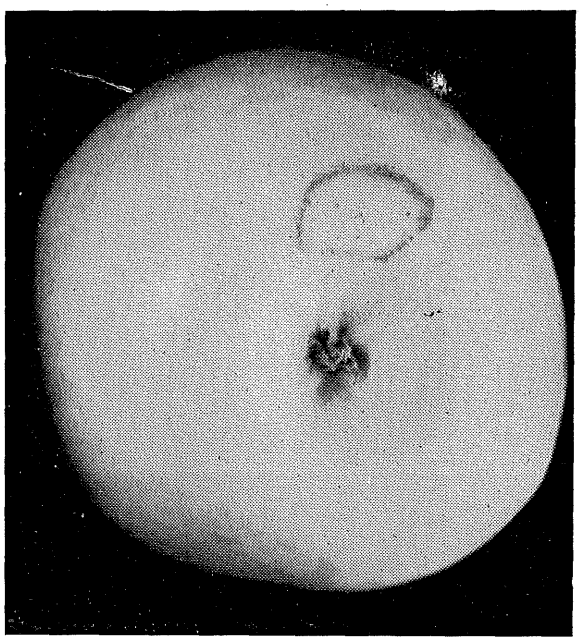

Fig. 1.—"Ring-marking" associated with the emulsifiable formulation of azinphos-ethyl.

Harvesting was carried out on April 5. Results are given in Table 7.

TABLE 7

PERCENTAGES OF WORMY AND STUNG FRUIT, TRIAL 9, 1962–63

Treatment	Percentage Wormy Fruit		Percentage Stung Fruit	
	Transformed Mean	Equivalent Mean*	Transformed Mean	Equivalent Mean*
Azinphos-methyl 0·05% ..	0·13	1·71	0·20	4·12
Azinphos-ethyl 0·05%	0·04	0·15	0·11	1·26
Mesurol 0·05%	0·07	0·54	0·16	2·44
Phosphamidon 0·04%	0·35	11·91	0·44	18·23
Untreated**		52·00		54·00
Necessary differences for significance 5%	0·09		0·10	
Necessary differences for significance 1%	0·12		0·14	

* Inverse sine transformation

** Data from untreated plots, which were obviously inferior, were not included in analysis

Azinphos-methyl, azinphos-ethyl and Mesurol were better than phosphamidon, which in turn was better than no treatment.

V. GENERAL COMMENTS

Variability in the level of infestation was apparent from trial to trial. The presence of untreated trees and in certain instances the use of a minimum number of spray applications may have contributed to the relatively high percentages of stung fruit, even in the better treatments.

The most conspicuous feature of the results is the reduced efficacy of DDT in trials later than Trial 1 (1958–59 season). By this time DDT resistance in codling moth had been established in America (Cutright 1954) and in some parts of Australia (Smith 1955; Morris and van Baer 1959; Lloyd 1960). The lack of control in the above trials and in some commercial orchards in the Stanthorpe district indicates the development of resistance to this material in Queensland.

Of the likely alternative materials tested, azinphos-ethyl, azinphos-methyl, carbaryl and Mesurol have proved effective. Each of these, however, has a range of properties which in commercial practice could influence the choice between them. A phytotoxicity described as "ring-marking" was associated with the emulsifiable formulation of azinphos-ethyl but not with the wettable powder. The excessive fruit shed and the fruit russet associated with carbaryl in Trial 4 was not repeated in some tests carried out in subsequent seasons.

On the results of the earlier trials, Bengston (1960) recommended the use of azinphos-methyl in the spray programme for apples in the Stanthorpe district. Subsequently (Bengston 1963, unpublished), azinphos-ethyl, carbaryl and Mesurol were, with respect to circumstances, recommended as alternatives.

VI. ACKNOWLEDGEMENTS

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