STUDIES ON CODLING MOTH CONTROL IN THE GRANITE BELT.

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SUMMARY.

The literature on Cydia pomonella **(L.) in Queensland is reviewed.**

The details of six orchard trials during 1949-50, 1954-55 and 1956-57 are given. The materials used in the several spray programmes were DDT, DDD (TDE), diazinon, dieldrin, endrin, malathion, methoxychlor, and parathion. Treatments were applied according to pre-determined programmes for each season, additional sprays, either alone or in combination, being used to control pests other than codling moth.

The results illustrate the variation in codling moth populations between orchards and seasons. Under the conditions of these trials none of the newer materials tested gave better results than DDT. It was concluded, therefore, that alterations to the existing codling moth spray programme cannot be justified.

I. INTRODUCTION.

Codling moth, *Cydia pomonella* (L.), was first recorded in Queensland infesting fruit in Brisbane (Tryon 1889). Most investigational work, however, with this serious pest has been carried out in districts centred on Stanthorpe in the Granite Belt, the commercial apple-producing area of the State.

Jarvis (1933, 1935, 1937) reported experiments and observations on control with insecticides, bandaging and lure trapping. Arsenate of lead, and a combination of white oil and nicotine sulphate, were among the most effective chemical controls. Ward and Ross (1938) further tested these and other combinations of spray materials, and also made observations on the seasonal activity of moths, using lure traps to sample populations with a view to devising a practicable method of timing spray applications. Ward and Groom (1940) conducted a spray trial comparing the efficacies of a fixed 3-weekly application programme with a programme in which the timing of spray applications was based on lure trap data. These authors concluded that lure trapping could form the basis for district advisory notices intimating the most suitable times to apply sprays. Caldwell (1948), following this system of spray timing, demonstrated that the use of DDT 0·1 per cent. was a distinct improvement on previous recommendations.

May (1948) confirmed the superiority of DDT, and suggested that reduction in cover sprays from six to four would not prejudice control. Alternative programmes covering a range of DDT concentrations were then tested (May 1949). It was also demonstrated (May 1950) that the calyx spray was not required when spring moth populations were small.

From these earlier trials and those for the 1949-50 trial reported in this paper, May (1952) concluded that the application of two sprays of DDT 0·1 per cent., three weeks apart, made to coincide with each of the two periods of major moth activity, was commercially desirable.

Commercial spray programmes covering the control of all major pests of apples were issued by May (1952) and May and Bengtson (1955). Although these satisfied the immediate needs of orchardists, disadvantages associated with the use of DDT in apple orchards and the advent of newer chemicals warranted continued studies; results of relevant orchard trials are reported in this paper.

II. MATERIALS AND METHODS.

(1) Materials.

The materials used were:—

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

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

Dieldrin.—An emulsifiable preparation containing 16 per cent. w/v active ingredient.

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

HETP.—An emulsifiable preparation containing 16–20 per cent. w/v *TEPP* as active ingredient.

Lead arsenate.—A powder containing 31 per cent. As_2O_5 as lead arsenate, and 1 per cent. dispersing agent; containing less than 0·5 per cent. water-soluble arsenic compounds.

Malathion.—An emulsifiable preparation containing 50 per cent. w/v active ingredient.

Methoxychlor.—An emulsifiable preparation containing 24 per cent. w/v active ingredient.

Nicotine sulphate.—A concentrate containing 40 per cent. w/w nicotine as nicotine sulphate.

Parathion.—An emulsifiable preparation containing 50 per cent. w/v active ingredient.

DDD (TDE).—An emulsion concentrate containing 30 per cent. w/v *p.p'* isomer.

Thiram.—A dispersible powder containing 80 per cent. w/w active ingredient.

Urea.—Containing 46 per cent. nitrogen as urea.

White oil.—Containing refined mineral oil, 74 per cent. w/v (82·5 per cent. by weight: unsulphonatable residue not less than 90 per cent.).

(2) Design of Trials.

Randomised blocks with a plot size of either one or two trees were used.

(3) Treatment Application.

Treatments were applied at a pressure of 200–250 lb. per sq. in., using a small power spray with a hand-operated lance. Complete tree cover was aimed at.

(4) Assessing Results.

Windfall and harvested fruit from plot trees were examined for larval damage. Where large numbers of harvested fruit were available random samples were taken.

A fruit was recorded as sound if there was no evidence of codling moth damage. Once damage was evident the fruit was classified as stung. In most trials the stung fruit were subdivided into blind stings, if larvae failed to develop, and wormy, if larvae developed to maturity.

Layout, spray combinations, detailed programmes, treatment application dates and other relevant data are given with the results.

III. RESULTS.

(1) 1949-50 Trials.

A 9 x 5 randomised block with single-tree plots of the variety Granny Smith was established on each of two orchards.

Sprays used were DDT 0·1 per cent.; lead arsenate 3 lb./100 gal.; HETP 1:800 with spreader; and parathion 0·02 per cent. (except where indicated as 0·04 per cent.).

Table 1.

SPRAY PROGRAMMES FOR 1949–50 TRIALS.

Programme.	Cover Sprays.					
	1 Nov. 8.	2 Nov. 30.	3 Dec. 27.	4 Jan. 10.	5 Jan. 31.	6 Feb. 2.
A	DDT	DDT	DDT + HETP	DDT	DDT	DDT
B	DDT	DDT + lead arsenate	HETP	DDT	DDT + lead arsenate	..
C	DDT	DDT	HETP	DDT	DDT	..
D	DDT	Parathion (0·04%)	..	DDT	DDT + lead arsenate	..
E	DDT	DDT + parathion	..	DDT	DDT + lead arsenate	..
F	DDT	DDT + HETP	..	DDT	DDT + lead arsenate	..
G	Parathion	Parathion	..	Parathion	Parathion	..
H	Parathion (0·04%)	Parathion	..	Parathion (0·04%)	Parathion	..
I	Untreated	Untreated	Untreated	Untreated	Untreated	Untreated

Prior to treatments all plots in both trials received uniform treatment as follows:—Trial 1: a semi-dormant spray (pale oil 4 gal., lime sulphur 4 gal., water 80 gal.); Trial 2: semi-dormant oil (1 in 16), and a calyx spray (lead arsenate paste 6 lb., lime sulphur 1½ gal., hydrated lime 6 lb., water 100 gal.).

Programmes with the standard (Programme A) consisting of six DDT applications are given in Table 1.

All windfall fruit were examined. Of the harvested fruit, on Trial 1 two loose bushels and on Trial 2 three loose bushels were taken as a sample per plot. Trial 1 was harvested on Apr. 18 and 19 and Trial 2 on Mar. 29 and 30: results are given in Table 2.

Table 2.

RESULTS OF 1949–50 TRIALS.

Programme.	Trial 1.				Trial 2.			
	Harvested Crop.		Total Crop.		Harvested Crop.		Total Crop.	
	Wormy.	Stung.	Wormy.	Stung.	Wormy.	Stung.	Wormy.	Stung.
	%	%	%	%	%	%	%	%
A	0·0	0·0	0·1	0·1	0·7	2·7	1·1	3·1
B	0·4	0·8	0·4	0·9	0·5	3·2	1·2	3·7
C	0·7	1·6	1·0	2·0	0·4	2·6	0·7	2·8
D	0·7	1·1	1·2	1·6	1·7	4·9	3·3	6·2
E	0·7	1·0	0·9	1·1	1·0	3·5	1·7	4·1
F	0·5	1·5	0·8	1·9	1·5	7·4	2·6	8·3
G	4·0	4·7	4·5	5·4	3·7	6·4	3·9	6·5
H	1·9	3·1	2·1	3·4	2·3	4·4	2·7	4·6
I	4·0	4·4	5·7	6·1	10·8	15·1	16·3	20·1
Differences necessary for significance 5%	3·0	3·2	3·3	3·4	3·4	5·8	3·7	5·9
Differences necessary for significance 1%	4·1	4·3	4·4	4·5	4·6	8·8	4·9	7·9

Codling moth infestations in these trials were not heavy and all treatments were significantly better than untreated.

(2) 1954-55 Trials.

An 8 x 4 randomised layout was used with single-tree (Delicious) plots in Trial 1, 2-tree (Jonathan) plots in Trial 2, and two separate blocks with single-tree (Granny Smith) plots as Trial 3.

Sprays used were DDT 0·1 per cent.; endrin 0·025 per cent. and 0·05 per cent.; dieldrin 0·05 per cent.; lead arsenate 3 lb./100 gal.; white oil 2½ pt./100 gal.; nicotine sulphate 1¼ pt./100 gal.; DDT 0·1 per cent.; thiram 1½ lb./100 gal.; urea 5 lb./100 gal.; and parathion 0·01 per cent.

Prior to treatments all plots in the trials received uniform applications of sprays. These included:—Trial 1, superior oil 3 in 100 while dormant; Trial 2, superior oil 3 in 100 while dormant, lime sulphur 1 in 30 at "pink", and lead

Table 3.

SPRAY PROGRAMMES FOR 1954–55 TRIALS.

Programme.	Cover Sprays.					
	1.	2.	3.	4.	5.	
	All Trials.	All Trials.	All Trials.	All Trials.	Trials 1 and 3.	Trial 2.
A	DDT	DDT + Lead arsenate + Parathion	Parathion	DDT	DDT + Lead arsenate + White oil	DDT + White oil + Nicotine sulphate
B	DDT	DDT + DDD + Parathion	Parathion	DDT	DDT + DDD	DDT + DDD
C	Endrin 0·025%	Endrin 0·025% + Lead arsenate + Parathion	Parathion	Endrin 0·025%	Endrin 0·025% + Lead arsenate	Endrin 0·025% + White oil + Nicotine sulphate
D	Endrin 0·025%	Endrin 0·025% + DDD + Parathion	Parathion	Endrin 0·025%	Endrin 0·025% + DDD	Endrin 0·025% + DDD
E	Endrin 0·05%	Endrin 0·05% + Parathion	Parathion	Endrin 0·05%	Endrin 0·05%	Endrin 0·05%
F	Dieldrin	Dieldrin + Parathion	Parathion	Dieldrin	Dieldrin	Dieldrin
Ga .. .. .. Trial 1 and Trial 3 (Block 1)	Programme A + Urea	Programme A + Urea	Parathion	Programme A + Urea	Programme A + Urea	..
Gb .. .. .. Trial 2 and Trial 3 (Block 2)	Programme A + Thiram	Programme A + Thiram	Parathion	Programme A + Thiram	Programme A + Thiram	..
H	Untreated	Untreated	Untreated	Untreated	Untreated	Untreated

Table 4.

RESULTS OF 1954–55 TRIALS.

Programme.	Percentage Fruit Stung.							
	Trial 1.				Trial 3.			
					Block 1.		Block 2.	
	Jan. 17.		Entire Crop.		Entire Crop.		Entire Crop.	
	Transformed Mean.	Equivalent Mean.	Transformed Mean.	Equivalent Mean.	Transformed Mean.	Equivalent Mean.	Transformed Mean.	Equivalent Mean.
A	7·7	1·8	14·4	6·1	53·2	64·1	38·2	38·3
B	7·2	1·6	13·6	5·5	50·7	59·8	34·9	32·7
C	13·0	5·1	20·0	11·7	65·2	82·4	53·9	65·2
D	15·1	6·8	21·9	13·9	69·9	87·6	54·8	66·8
E	13·1	5·1	27·4	21·2	65·8	83·1	49·9	58·5
F	24·9	17·7	34·0	31·4	73·5	91·9	61·9	77·8
G	3·8	0·4	10·7	3·5	50·7	59·9	34·3	31·7
H	24·6	17·3	42·4	45·5	71·0	89·4	61·4	77·0
Differences necessary for significance 5%	7·5		9·9		8·8		6·7	
Differences necessary for significance 1%	10·2		13·5		11·9		9·2	

arsenate 3 lb., hydrated lime 3 lb., casein spreader 1 lb., colloidal sulphur 2 lb., lime sulphur ½ in 100 of water at "calyx"; Trial 3, superior oil 3 in 100 while dormant.

Programmes are given in Table 3, and application dates of cover sprays were as follows:—

Trial 1: Nov. 8, Nov. 26-27, Dec. 12, Jan. 15, and Feb. 3;

Trial 2: Nov. 2, Nov. 23, Dec. 6, Jan. 1, and Feb. 1;

Trial 3: Nov. 6, Nov. 24, Dec. 5–6, Jan. 1, and Feb. 2.

As heavy stinging was occurring, and at the request of the orchardist, an additional DDT treatment was applied on Jan. 20 to trees concerned with spray programmes C, D, and F in Trial 1.

Infestation was negligible in Trial 2. Trial 1 was harvested on Mar. 31 and Trial 3 during the period Apr. 20 to May 5. In Trial 1 a progress count of stung fruit was made on Jan. 17. All relevant results are given in Table 4.

The use of DDT gave better protection than the other materials, but none of the programmes was entirely satisfactory in controlling the heavy pest populations encountered. The addition of either urea or thiram did not interfere with the insecticidal action of DDT sprays.

(3) 1956-57 Trial.

This consisted of an 8 x 4 randomised block with single-tree plots of the variety Granny Smith.

Table 5.

RESULTS OF 1956–57 TRIAL.

Treatment.	Programme.	Percentage Fruit Stung.		Percentage Blind Stings/ Total Stings.	
		Transformed Mean.	Equivalent Mean.	Transformed Mean.	Equivalent Mean.
A. DDT 0·1%	Recommended	21·8	13·8	38·2	38·3
B. Parathion 0·01% ..	Recommended	34·6	32·2	28·2	22·3
C. Malathion 0·05% ..	Recommended	30·0	25·1	27·4	21·2
D. Diazinon 0·1% ..	Recommended	23·8	16·2	35·5	33·7
E. Methoxychlor 0·1% ..	Recommended	24·0	16·5	22·1	14·2
F. DDT 0·1%	Fortnightly	18·6	10·2	51·0	60·4
G. Malathion 0·05% ..	Fortnightly	24·6	17·3	34·5	32·1
H. Untreated	..	37·2	36·6	9·4	2·7
Differences necessary for significance 5%		8·9		12·7	
Differences necessary for significance 1%		12·1		17·3	

Sprays used are given with results in Table 5. Applications of treatments A to E were made in accordance with the recommended apple pest spraying programme (May and Bengtson 1955). Treatments F and G were applied fortnightly.

Prior to treatments all plots received uniform applications of superior oil 3 in 100 while dormant, and Bordeaux 10–10–100 at green tip.

During the trial all trees received a spray of DDD 0·1 per cent. on Nov. 27 and two sprays of parathion 0·01 per cent. on Nov. 27 and Dec. 11 to control incidental pests.

Treatments A to E were applied on Nov. 4 and 7 and Jan. 8 and 25; treatments F and G were applied on Nov. 4 and 22, Dec. 6 and Jan. 3 and 17. Harvesting was carried out between Apr. 30 and May 15, and results are given in Table 5.

With this moderate infestation none of the materials was better than DDT although diazinon was almost as good.

IV. GENERAL COMMENTS.

These trials illustrate the variations in codling moth infestation from orchard to orchard and from season to season in the Stanthorpe district and the difficulty of holding damage by heavy infestations to an economic level.

The levels of population existing in trials from untreated and inferior treatment plots provided ideal conditions for comparing the several treatments and programmes. None of the newer materials tested has given better results than DDT, but diazinon and methoxychlor may warrant additional work. The results indicate also the need for long-term detailed investigations into the timing of sprays. The effect of treatments on other pests of apples, especially fruit fly, *Strumeta tryoni* (Frogg.), and mites, *Tetranychus* spp., should not be overlooked in future codling moth control studies.

At present, alterations in the codling moth spray programme of May and Bengtson (1955) are not indicated.

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