# TOBACCO LEAF-PEST CONTROL INVESTIGATIONS, 1949-1955

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### SUMMARY

**During 1949-1955, 7 insecticide screening trials, 3 yield trials, 4 taint trials and one seedbed phytotoxicity trial were carried through.**

**The inefficiency of dusts, and the limitations of many insecticides for use in the control of tobacco pests, were demonstrated.**

**Endrin, and dieldrin at a greater concentration, were clearly the best materials for use on tobacco where the looper** *Plusia argentifera* **Gn. must be controlled. DDT was the most satisfactory against budworms,** *Heliothis armigera* **Hb. and** *H. punctigera* **Wallengr., and for the control of the cluster grub,** *Prodenia litura* **(F.). DDT, endrin and dieldrin as protective sprays were effective in controlling leaf-miner,** *Gnorimoschema operculella* **(Zell.).**


## I. INTRODUCTION

In 1948, tobacco leaf-pest control practices in Queensland included the use of lead arsenate on young plants as dust, spray or bait for the leaf-chewing noctuids (Smith 1952) and DDT for the leaf miner, *Gnorimoschema operculella* (Zell.). The expansion of irrigated areas in subsequent years was associated with consistent and destructive attacks by the tobacco looper, *Plusia argentifera* Gn., in particular in exploratory plots grown by agricultural officers in the Lower Burdekin district preliminary to general expansion. The reason for the increased pest status of the tobacco looper was the change permitted by irrigation from early summer to spring planting when more of the cropping season occurred during the period of maximum activity of the insect (Smith 1959).

Growers were faced with the difficulty of controlling the tobacco looper on large plants and well-established practices were not suitable for this purpose. The present paper deals with investigations of insecticidal control of the leaf pests, particularly *P. argentifera,* and covers pest kills, tainting and phytotoxicity.

## II. MATERIALS

*DDT.*—An emulsion concentrate containing 20 per cent. w/v *p.p′* isomer in toluol.

A dispersible concentrate containing 50 per cent. w/v *p.p′* isomer in solubilizing agent.

A dispersible powder containing 50 per cent. w/w *p.p′* isomer.

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A dust containing 5 per cent. w/w *p.p′* isomer.

A dust containing 2 per cent. w/w *p.p′* isomer.

An emulsion concentrate containing 25 per cent. w/v *p.p′* isomer.

An emulsifiable concentrate containing 20 per cent. w/v *p.p′* isomer in aromatic (high range) solvent.

An emulsifiable concentrate containing 25 per cent. w/v *p.p′* isomer in solvent naphtha.

An emulsifiable concentrate containing 20 per cent. w/v *p.p′* isomer in benzol.

*Lead arsenate.*—A dispersible powder containing 31 per cent. w/w $As_2O_5$.

A dust containing 15·5 per cent. w/w $As_2O_5$.

*Parathion.*—An emulsifiable concentrate containing 20 per cent. w/v active ingredient in aromatic (high range) solvent.

A dispersible powder containing 15 per cent. w/w active ingredient.

An emulsifiable concentrate containing 25 per cent. w/v active ingredient in emulsifier.

*Demeton.*—An emulsifiable concentrate containing 50 per cent. w/v active ingredient in emulsifier.

*TTC.*—A dispersible powder containing 10 per cent. w/w bis (p-chlorophenoxy) methane.

*White oil.*—An emulsion concentrate containing 74 per cent. w/v refined mineral oil; unsulphonatable residue not less than 90 per cent.

*BHC*—An emulsifiable concentrate containing 7 per cent. w/v gamma isomer and other isomers in mineral turpentine.

An emulsifiable concentrate containing 16 per cent. w/v gamma isomer (lindane) in toluol.

A dispersible powder containing 16 per cent. w/w gamma isomer (lindane).

An emulsifiable concentrate containing 14 per cent. w/v gamma isomer (lindane).

*Toxaphene.*—An emulsifiable concentrate containing 60 per cent w/v chlorinated camphenes.

An emulsifiable concentrate containing 100 per cent. w/v chlorinated camphenes.

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

An emulsifiable concentrate containing 15 per cent. w/v active ingredient in aromatic (low range) solvent.

A dispersible powder containing 50 per cent. w/w active ingredient.

A dust containing 5 per cent. w/w active ingredient.

An emulsifiable concentrate containing 20 per cent. w/v active ingredient in solvent naphtha.

*Mipafox.*—A miscible solution containing 50 per cent. w/v active ingredient (anhydrous).

*Pyrethrum/piperonyl butoxide.*—A dust containing 0·05 per cent. w/w pyrethrins and 0·8 per cent. w/w piperonyl butoxide.

*Pyrethrum/piperonyl butoxide/DDT.*—A dust containing 0·048 per cent. w/w pyrethrins, 0·8 per cent. w/w piperonyl butoxide and 2 per cent. w/w. *p.p′* isomer of DDT.

*Chlordane.*—An emulsifiable concentrate containing 82 per cent. w/v active ingredient in deodorized kerosene.

*Endrin.*—An emulsifiable concentrate containing 20 per cent. w/v active ingredient in aromatic (low range) solvent.

An emulsifiable concentrate containing 18·5 per cent. w/v active ingredient.

*DDD.*—An emulsion concentrate containing 20 per cent. w/v active ingredient in solvent naphtha.

*Aldrin.*—An emulsifiable concentrate containing 23 per cent. w/v active ingredient.

*Aromatic (high range) solvent.*—A solvent containing 95 per cent. v/v aromatics, having a distillation range 138°-177° C.

*Aromatic (low range) solvent.*—A solvent containing 95 per cent. v/v aromatics, having a distillation range 112°-162° C.

*Solvent naphtha.*—A high commercial grade.

*Emulsifier.*—A commercial sodium lauryl sulphonate.

*Benzol.*—A commercial grade.

*Toluol.*—A commercial grade.

## III. PEST KILLS

Seven screening trials and 3 yield trials were carried through.

### (a) Methods

#### (i) Screening Trials

Sites were selected in established plantings where loopers were active, or crops were grown for the special purpose, receiving sufficient insecticidal protection in the establishment period to allow growth to proceed in the presence of other pests.

A medium-sized plant in active growth was aimed at for trial purposes to ensure attractiveness to larvae and moths and to avoid the increased parasite activity often found on older plants. All trials were furrow irrigated.

The plot size was a definite number of plants in each trial, varying from 2 to 5 in different trials, depending on the number of larvae present per plant. The method of varying the plot size to give a minimum number of larvae per plot prior to treatment was abandoned after an unsuccessful attempt during 1952 to determine synergistic effects between DDT and lead arsenate. Oviposition during the post-treatment period resulted in disproportionate population increases due to the variable plot size.

Insecticides were applied with a knapsack sprayer or a small hand dust gun. Special efforts were made to obtain a complete cover on both sides of each leaf. In most trials framed screens of hessian were used to restrict sprays and dusts.

Loopers at all stages were counted on each plot the day prior to treatment and again at intervals up to 14 days after treatment. The technique of preparing the plant for the pre-treatment count varied with its nature. If necessary, the inflorescence and axillary branches were removed and the area was cleared of weeds.

Details of layout, plot size, treatments and other relevant information are given with the results.

**(ii) Yield Trials**

Only sprays by knapsack sprayer and dry baits by hand were used.

Five random plants per plot were used for insect counts in these trials with the following exceptions. Ten plants were used for the first 3 counts in the 1950 and the 1953 trials when the plants were small; 12 plants were used to represent each control strip in the 1953 and the 1954 trials.

In addition to loopers, the larvae of *Heliothis* species (*H. armigera* Hb. and *H. punctigera* Wallengr.) and *Prodenia litura* F., and the mines of the leaf-miner, were counted. In the 1950 trial the pupal clusters of a Braconid, commonly parasitic on *P. argentifera* larvae, were also recorded.

The percentage of leaf area undamaged was visually estimated a week prior to the beginning of harvests in the 1950 trial. The leaves of 5 random plants were used, the numbers ranging from 78 to 100 per plot.

As the crop ripened, plots were harvested separately and labelled sticks of leaf were cured and afterwards bulked as parcels. When ready for grading, the parcels were weighed and recorded by plots. Samples of each grade were given an assessed value by a trade appraiser and plot values were calculated accordingly.

## (b) Results

### (i) Screening Trials, 1949

Two trials were carried through at Claredale during December 9-16. In both trials the layout was a 14 x 4 randomized block with plot sizes of 3 plants (Trial 1) and 2 plants (Trial 2). Plants were 2-3 ft high in Trial 1 and 6-7 ft in Trial 2. Results are presented in Table 1 as mean survival indices, calculated by dividing numbers of larvae surviving by numbers before treatment. Mean numbers (and range) of larvae per plot prior to treatment were 35·2 (16-72) in Trial 1 and 21·6 (8-48) in Trial 2.

**Table 1**

MEAN SURVIVAL OF *Plusia argentifera*

(*Screening Trials, Claredale*, 1949)

| Treatment | Survival Indices | | | |
|---|---|---|---|---|
| | Trial 1 | | Trial 2 | |
| | After 3 Days | After 7 Days | After 3 Days | After 7 Days |
| DDT toluol emulsion 0·2% | 0·22 | 0·10 | 0·08 | 0·08 |
| DDT toluol emulsion 0·1% | 0·28 | 0·18 | 0·09 | 0·12 |
| DDT solubilized spray 0·3% | 0·42 | 0·49 | 0·08 | 0·12 |
| dispersible powder 0·4% | 0·62 | 0·46 | 0·12 | 0·12 |
| DDT dispersible powder 0·2% plus white oil 1 : 200 | 0·50 | 0·50 | 0·03 | 0·03 |
| DDT dust 5% | 0·99 | 1·14 | 0·47 | 0·28 |
| DDT dust 2% | 0·98 | 0·83 | 0·13 | 0·23 |
| Lead arsenate spray 3 lb / 50 gal | 0·08 | 0·03 | 0·01 | 0·00 |
| Lead arsenate dust | 0·54 | 0·38 | 0·09 | 0·08 |
| DDT toluol emulsion 0·2% plus lead arsenate 1½ lb / 50 gal | 0·32 | 0·23 | 0·00 | 0·01 |
| Parathion aromatic (high range) emulsion 0·05% | 0·07 | 0·26 | 0·03 | 0·01 |
| Parathion aromatic (high range) emulsion 0·01% | 0·22 | 0·50 | 0·12 | 0·10 |
| DDT toluol emulsion 0·4% plus lead arsenate 3 lb / 50 gal | 0·10 | 0·05 | .. | .. |
| Untreated | .. | .. | 0·44 | 0·34 |
| Untreated | 1·96 | 2·51 | 0·58 | 0·57 |
| Necessary differences for significance— | | | | |
| All treatments 5% | 0·56 | 0·66 | 0·24 | 0·22 |
| 1% | 0·75 | 0·88 | 0·32 | 0·29 |
| Excluding 6th, 7th and 14th 5% | 0·25 | 0·27 | .. | .. |
| 1% | 0·34 | 0·36 | .. | .. |
| Excluding 6th, 13th and 14th 5% | .. | .. | 0·11 | .. |
| 1% | .. | .. | 0·15 | .. |
| Excluding 6th, 7th, 13th and 14th 5% | .. | .. | .. | 0·12 |
| 1% | .. | .. | .. | 0·16 |

The figures demonstrate the efficacy of DDT and lead arsenate and the superiority of sprays over dusts. In Trial 1 the population increase due to egg hatching provided conditions which revealed the reduction in residual activity of parathion within 7 days of treatment.

## (ii) Screening Trials, 1951

Two trials were carried through between November 29 and December 17, one at Kalamia and one at Claredale. The respective layouts were 13 x 4 and 14 x 4 randomized blocks with plot sizes of 3 plants 4-6 ft high. Mean numbers (and ranges) of loopers per plot before treatment were 28·8 (15-73) at Kalamia and 22·0 (15-75) at Claredale. To indicate population fluctuations, percentage natural survival is given in Table 2. An adjustment was made in the observed percentage survival figures to allow comparisons from day to day. The percentages on each day were multiplied by the factor necessary to bring the untreated plot survival percentages to 100. The adjusted percentages are presented in Table 3.

**Table 2**

Percentage Natural Survival

(*Screening Trials, Kalamia and Claredale*, 1951)

| Trial | After 1 Day | After 3 Days | After 7 Days | After 11 Days | After 13 Days |
|---|---|---|---|---|---|
| Kalamia .. | 112 | 89 | 118 | 249 | .. |
| Claredale .. | 97 | 52 | 49 | .. | 45 |

**Table 3**

Mean Adjusted Percentage Survival

(*Screening Trials, Kalamia and Claredale*, 1951)

| Treatment | Kalamia | | | | Claredale | | | |
|---|---|---|---|---|---|---|---|---|
| | After 1 Day | After 3 Days | After 7 Days | After 11 Days | After 1 Day | After 3 Days | After 7 Days | After 13 Days |
| DDT toluol emulsion 0·1% .. .. | 39 | 37 | 43 | 65 | 39 | 33 | 32 | 92 |
| DDT toluol emulsion 0·1% plus lead arsenate 3 lb / 50 gal .. .. | 47 | 25 | 14 | 46 | 42 | 17 | .. | 12 |
| Lead arsenate spray 3 lb / 50 gal plus white oil 1 : 250 .. .. .. | 83 | 47 | 30 | 65 | 64 | 20 | 22 | 40 |
| BHC emulsion 0·03% with other isomers .. .. .. .. .. | 68 | 14 | 45 | 143 | 21 | 6 | 59 | 192 |
| BHC emulsion 0·03% with other isomers plus DDT toluol emulsion 0·1% .. .. .. .. | 44 | 9 | 32 | 91 | 10 | 2 | 7 | 90 |
| Demeton emulsion 0·025% .. .. | 98 | 105 | 73 | 100 | .. | .. | .. | .. |
| Toxaphene 60% emulsion 0·1% .. | .. | .. | .. | .. | 19 | 4 | 6 | 44 |
| Dieldrin 16% emulsion 0·05% .. | 44 | 11 | 16 | 49 | 30 | 6 | 5 | 27 |
| Dieldrin 16% emulsion 0·1% .. .. | 39 | 4 | 2 | 17 | 5 | 2 | 1 | 1 |
| Demeton emulsion 0·075% .. .. | 84 | 91 | 90 | 130 | 88 | 82 | 99 | 175 |
| Mipafox spray 0·05% .. .. .. | 76 | 109 | 102 | 86 | 77 | 92 | 100 | 136 |
| Pyrethrum dust 0·05% plus piperonyl butoxide 0·8% .. .. .. | 33 | 31 | 72 | 87 | 68 | 101 | 150 | 145 |
| Pyrethrum dust 0·048% plus piperonyl butoxide 0·8% plus DDT 2% .. | 57 | 61 | 76 | 103 | 84 | 85 | 91 | 60 |
| Chlordane emulsion 0·1% .. .. | .. | .. | .. | .. | 45 | 33 | 62 | 83 |
| Untreated .. .. .. .. | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Necessary differences for significance 5% | 26 | 32 | 44 | 52 | 20 | 33 | 76 | 111 |
| Necessary differences for significance 1% | 35 | 43 | 59 | 70 | 26 | 44 | 102 | 148 |

Dieldrin was efficacious in both initial and residual toxicity. Toxaphene was promising. BHC had high toxicity but brief residual life. Chlordane produced moderate kills, but pyrethrum, mipafox and parathion gave no promise in these two trials. Observations during counting indicated that lead arsenate, more than other insecticides, killed larvae slowly, permitting some which were incapable of feeding to be included in the count.

### (iii) Screening Trial, 1953

This was carried through at Claredale during December 4-23. The layout was a 17 x 4 randomized block with plots of 5 tall plants. Results are presented in Table 4 as percentage survival of loopers 1 day after treatment. Few remained on any except untreated plots after 3 days. Mean of plot counts (and range) prior to treatment was 41·2 (30-63).

**Table 4**

PERCENTAGE SURVIVAL ONE DAY AFTER TREATMENT

(*Screening Trial, Claredale*, 1953)

| Treatment | Transformed Mean* | Equivalent Mean (%) |
|---|---|---|
| Endrin 20% emulsion 0·05% | 3·1 | 0·3 |
| Endrin 20% emulsion 0·025% | 14·3 | 6·1 |
| Endrin 20% emulsion 0·0125% | 25·0 | 17·9 |
| Dieldrin aromatic (low range) emulsion 0·05% | 15·3 | 7·0 |
| Dieldrin dispersible powder 0·05% | 28·8 | 23·2 |
| Dieldrin dust 5% | 26·6 | 20·1 |
| Parathion aromatic (high range) emulsion 0·03% | 16·1 | 7·7 |
| Parathion aromatic (high range) emulsion 0·02% | 23·5 | 15·9 |
| Parathion aromatic (high range) emulsion 0·01% | 32·7 | 29·2 |
| Parathion dispersible powder 0·03% | 21·1 | 13·0 |
| Parathion dispersible powder 0·02% | 19·0 | 10·6 |
| Parathion dispersible powder 0·01% | 25·2 | 18·1 |
| BHC dispersible powder 0·03% | 18·8 | 10·4 |
| BHC toluol emulsion 0·03% | 32·3 | 28·6 |
| DDT toluol emulsion 0·1% plus lead arsenate 3 lb / 50 gal | 34·2 | 31·6 |
| Untreated (2 plots) | (83·7) | 98·8 |
| Necessary differences for significance 5% | 7·14 | .. |
| Necessary differences for significance 1% | 9·63 | .. |

* Inverse sine.

Endrin was the best insecticide at practical levels, achieving a large kill after 1 day compared with the DDT plus lead arsenate spray adopted as a standard.

### (iv) Screening Trials, 1955

Two trials were carried through, at Claredale beginning on November 16 and at Ayr beginning on November 25, with 6 x 4 randomized block layouts. Plots of 8 tall plants were treated and 3 middle plants were used for counts. Results of counts of *P. argentifera* larvae are given in Table 5 (Claredale) and Table 7

(Ayr) as mean numbers per plant. *Heliothis* species were also present and similar data recorded concerning these is presented in Table 6 (Claredale) and Table 8 (Ayr). Natural population depression limited the number of counts following treatment.

**Table 5**

MEAN NUMBERS OF *Plusia argentifera* LARVAE

(*Screening Trial, Claredale*, 1955)

| Treatment | Pretreatment | | After 1 Day | | After 3 Days | |
|---|---|---|---|---|---|---|
| | Trans-formed Mean* | Equiv. Mean No. | Trans-formed Mean* | Equiv. Mean No. | Trans-formed Mean* | Equiv. Mean No. |
| DDD emulsion 0·05% .. .. .. | 2·42 | 5·36 | 1·46 | 1·63 | 1·47 | 1·66 |
| DDD emulsion 0·1% .. .. .. | 3·28 | 10·26 | 1·61 | 2·09 | 1·06 | 0·62 |
| DDD emulsion 0·2% .. .. .. | 3·09 | 9·05 | 1·76 | 2·60 | 0·96 | 0·42 |
| Endrin 20% emulsion 0·05% .. .. | 3·05 | 8·80 | 0·84 | 0·21 | 0·71 | 0·00 |
| Dieldrin aromatic (low range) emulsion 0·05% .. .. .. .. | 2·89 | 7·85 | 1·31 | 1·22 | 0·84 | 0·21 |
| Untreated .. .. .. .. .. | 2·48 | 5·65 | 2·03 | 3·62 | 1·62 | 2·12 |
| Necessary differences for significance 5% | 1·55 | .. | 0·86 | .. | 0·47 | .. |
| Necessary differences for significance 1% | 2·14 | .. | 1·19 | .. | 0·65 | .. |

$* \sqrt{x + \frac{1}{2}}$

**Table 6**

MEAN NUMBERS OF LARVAE OF *Heliothis* SPECIES

(*Screening Trial, Claredale*, 1955)

| Treatment | Pretreatment | | After 1 Day | | After 3 Days | | After 7 Days | |
|---|---|---|---|---|---|---|---|---|
| | Trans-formed Mean* | Equiv. Mean No. | Trans-formed Mean* | Equiv. Mean No. | Trans-formed Mean* | Equiv. Mean No. | Trans-formed Mean* | Equiv. Mean No. |
| DDD emulsion 0·05% .. .. .. | 2·38 | 5·16 | 1·34 | 1·30 | 0·96 | 0·42 | 1·38 | 1·40 |
| DDD emulsion 0·1% .. .. .. | 1·72 | 2·46 | 1·19 | 0·92 | 0·96 | 0·42 | 2·28 | 4·70 |
| DDD emulsion 0·2% .. .. .. | 2·36 | 5·07 | 0·96 | 0·42 | 0·71 | 0·00 | 0·71 | 0·00 |
| Endrin 20% emulsion 0·05% .. .. | 2·24 | 4·52 | 1·26 | 1·09 | 1·26 | 1·09 | 2·12 | 3·99 |
| Dieldrin aromatic (low range) emulsion 0·05% .. .. .. .. | 2·70 | 6·79 | 1·68 | 2·32 | 0·93 | 0·36 | 0·84 | 0·21 |
| Untreated .. .. .. .. | 2·59 | 6·21 | 2·71 | 6·84 | 3·19 | 9·68 | 3·89 | 14·63 |
| Necessary differences for signifiance 5% | 1·07 | .. | 0·92 | .. | 0·69 | .. | 1·97 | .. |
| Necessary differences for signifiance 1% | 1·48 | .. | 1·27 | .. | 0·96 | .. | 2·73 | .. |

$* \sqrt{x + \frac{1}{2}}$

**Table 7**

Mean Numbers of *Plusia argentifera* Larvae

(*Screening Trial, Ayr*, 1955)

| Treatment | Pretreatment | | After 1 Day | |
|---|---|---|---|---|
| | Transformed Mean* | Equiv. Mean No. | Transformed Mean* | Equiv. Mean No. |
| DDD emulsion 0·05% .. .. .. | 3·19 | 9·68 | 2·47 | 5·60 |
| DDD emulsion 0·1% .. .. .. | 3·61 | 12·53 | 2·11 | 3·95 |
| DDD emulsion 0·2% .. .. .. | 3·70 | 13·19 | 1·46 | 1·63 |
| Endrin 20% emulsion 0·05% .. .. | 4·29 | 17·90 | 0·93 | 0·36 |
| Dieldrin aromatic (low range) emulsion 0·05% .. .. .. .. .. | 2·71 | 6·84 | 1·26 | 1·09 |
| Untreated .. .. .. .. .. | 4·11 | 16·39 | 3·60 | 12·46 |
| Necessary difference for significance 5% | 1·76 | .. | 0·83 | .. |
| Necessary difference for significance 1% | 2·43 | .. | 1·15 | .. |

$* \sqrt{x + \frac{1}{2}}$

**Table 8**

Mean Numbers of Larvae of *Heliothis* Species

(*Screening Trial, Ayr*, 1955)

| Treatment | Pretreatment | | After 1 Day | | After 3 Days | | After 7 Days | |
|---|---|---|---|---|---|---|---|---|
| | Transformed Mean* | Equiv. Mean No. | Transformed Mean* | Equiv. Mean No. | Transformed Mean* | Equiv. Mean No. | Transformed Mean* | Equiv. Mean No. |
| DDD emulsion 0·05% .. .. .. | 4·46 | 19·39 | 1·42 | 1·52 | 1·06 | 0·62 | 1·82 | 2·81 |
| DDD emulsion 0·1% .. .. .. | 5·09 | 25·41 | 1·44 | 1·57 | 0·84 | 0·21 | 1·56 | 1·93 |
| DDD emulsion 0·2% .. .. .. | 4·88 | 23·31 | 1·34 | 1·30 | 0·84 | 0·21 | 1·13 | 0·78 |
| Endrin 20% emulsion 0·05% .. .. | 5·10 | 25·51 | 2·64 | 6·47 | 1·60 | 2·06 | 1·99 | 3·46 |
| Dieldrin aromatic (low range) emulsion 0·05% .. .. .. .. .. | 5·80 | 33·14 | 2·93 | 8·08 | 1·31 | 1·22 | 2·56 | 6·05 |
| Untreated .. .. .. .. .. | 5·22 | 26·75 | 4·85 | 23·02 | 3·46 | 11·47 | 4·30 | 17·99 |
| Necessary differences for significance 5% | 1·53 | .. | 1·17 | .. | 1·08 | .. | 1·27 | .. |
| Necessary differences for significance 1% | 2·11 | .. | 1·62 | .. | 1·50 | .. | 1·76 | .. |

$* \sqrt{x + \frac{1}{2}}$

Despite small populations, the results, using dieldrin as a new standard, suggest that DDD has only moderate toxicity to loopers and is little better than dieldrin and endrin against *Heliothis* species at normal levels.

### (v) Yield Trial, 1950

The yield trial carried through at Claredale in 1950 was the first of its type in these investigations. Leaf was harvested on 4 days between November 28 and December 21. The 6 x 4 layout included an untreated plot as one of the randomized treatments. Plots were 6 rows x 57 ft with 4 rows x 57 ft (0·01 ac) as data area. Details of materials and timing of treatment programmes are set out in Table 9; the DDT formulation used was the toluol emulsion. Results of yields, leaf value and leaf damage are given in Table 10 with looper populations in November; counts on September 28 and October 9 rarely exceeded 0·15 per plant. Data on populations of parasites and pests other than the tobacco looper are presented in Table 11.

**Table 9**

TREATMENT PROGRAMMES

(*Yield Trial, Claredale*, 1950)

| Programme | 28–ix–50 | 5–x–50 | 24–x–50 | 15–xi–50 |
|---|---|---|---|---|
| 1 | DDT spray 0·1% | DDT spray 0·1% | DDT spray 0·1% | DDT spray 0·1% |
| 2 | DDT spray 0·2% | DDT spray 0·2% | DDT spray 0·2% | DDT spray 0·2% |
| 3 | DDT spray 0·2% plus lead arsenate 1½ lb /50 gal | DDT spray 0·2% plus lead arsenate 1½ lb /50 gal | DDT spray 0·2% plus lead arsenate 1½ lb /50 gal | Lead arsenate spray 1½ lb/50 gal |
| 4 | As 3 .. .. | As 3 .. .. | Lead arsenate spray 3 lb / 50 gal | Bran bait containing 5% lead arsenate |
| 5 | As 3 .. .. | As 3 .. .. | As 3 .. .. | DDT spray 0·2% plus lead arsenate 1½ lb / 50 gal |
| 6 | Nil | Nil | Nil | Nil |

**Table 10**

YIELDS, APPRAISED VALUES, LOOPER COUNTS AND LEAF DAMAGE

(*Yield Trial, Claredale*, 1950)

| Programme | Mean Yield (lb/ac) | Appraised Value (£/ac) | Immature Loopers (Insects/Plant) | | Index of Leaf Area Undamaged 22.xi.50 (Max. area = 100) |
|---|---|---|---|---|---|
| | | | 7.xi.50 | 22.xi.50 | |
| 1 .. .. .. | 1132·5 | 377·0 | 1·48 | 2·65 | 92·8 |
| 2 .. .. .. | 1049·0 | 340·2 | 2·98 | 2·25 | 91·0 |
| 3 .. .. .. | 1007·5 | 311·8 | 2·12 | 1·70 | 94·5 |
| 4 .. .. .. | 965·5 | 330·2 | 1·90 | 3·00 | 90·2 |
| 5 .. .. .. | 1126·8 | 368·5 | 2·40 | 2·40 | 90·0 |
| 6 .. .. .. | 824·5 | 261·5 | 1·35 | 2·10 | 83·5 |
| Necessary differences for significance 5% | 216·5 | 96·5 | 1·02 | 2·18 | 5·5 |
| Necessary differences for significance 1% | 299·4 | 133·4 | 1·41 | 3·01 | 7·6 |

**Table 11**

OTHER PEST AND PARASITE POPULATIONS

(*Yield Trial, Claredale*, 1950)

| Programme | Numbers/Plant | | | | | | |
|---|---|---|---|---|---|---|---|
| | 11. ix. 50 | 7. xi. 50 | | | 22. xi. 50 | | |
| | *G. operculella* Leaf Mines | *Heliothis* Species Larvae | *Prodenia litura* Larvae | Braconid Pupal Clusters | *Heliothis* Species Larvae | *Prodenia litura* Larvae | Braconid Pupal Clusters |
| 1 | 0 | 0·075 | 0·075* | 0·025 | 0 | 0·05 | 0·50 |
| 2 | 0 | 0 | 0·05 * | 0 | 0 | 0 | 0·55 |
| 3 | 0·0125 | 0·025 | 0·125 | 0·025 | 0·65 | 0·50 | 0·15 |
| 4 | 0·0125 | 0 | 0·125* | 0 | 0·30 | 0·60 | 0·45 |
| 5 | 0 | 0·075 | 0·15** | 0 | 0·05 | 0·05 | 0·35 |
| 6 | 0·94 | 0·325 | 0·025 | 0·05 | 0·20 | 0·80 | 0·60 |

* These plots had 1 cluster of larvae per plant in addition to the solitary larvae counted.

All the spray programmes were of value in protecting leaves in this trial. Pest populations were small but persistent and untreated plants suffered a distinct though small loss of yield. The numbers of Braconid pupal clusters indicate moderate parasitism of *P. argentifera* during November and may explain the relative smallness of populations of that pest.

### (vi) Yield Trial, 1953

This trial was carried through at Claredale between early September, 1953, and early January, 1954. The layout was a 4 x 6 randomized block with 4 control strips in place of randomized control plots. Treatment plots were 8 rows x 35 ft with a data area 6 rows x 33 ft (0·018 ac); control strips were 32 rows x 13 ft with a data area 24 rows x 11 ft (0·024 ac). Details of materials and timing of treatment programmes are set out in Table 12; the insecticide formulations were DDT toluol emulsion and dieldrin aromatic (low range) emulsion. Results of yields and values are presented in Table 13. Periodic insect counts are set out in Figures 1-4: the major differences are statistically sound in all instances.

At the frequency used, both dieldrin and DDT satisfactorily protected the crop from the pest complex demonstrated in the graphs. Untreated plants were badly damaged. In the graphs the superiority of DDT over dieldrin for *Heliothis* control, and of dieldrin over DDT for looper control, is apparent. Both prevented leaf-miner attack.

**Table 12**

TREATMENT PROGRAMMES

(*Yield Trial, Claredale*, 1953)

| Date | Programme 1 | Programme 2 | Programme 3 | Programme 4 |
|---|---|---|---|---|
| 17. ix. 53 | DDT spray 0·1% | Dieldrin spray 0·05% | DDT spray 0·1% plus lead arsenate 3 lb/50 gal | DDT spray 0·1% |
| 24. ix. 53 | DDT spray 0·1% | Dieldrin spray 0·05% | DDT spray 0·1% plus lead arsenate 3 lb/50 gal | DDT spray 0·1% |
| 10. x. 53 | Dieldrin spray 0·05% | Dieldrin spray 0·05% | DDT spray 0·1% | DDT spray 0·1% |
| 12. x. 53 | .. | .. | Bran bait containing 5% lead arsenate | .. |
| 22–23. x. 53 | Dieldrin spray 0·05% | Dieldrin spray 0·05% | DDT spray 0·1% | DDT spray 0·1% |
| 29–30. x. 53 | Dieldrin spray 0·05% | Dieldrin spray 0·05% | DDT spray 0·1% | DDT spray 0·1% |
| 9–10. xi. 53 | Dieldrin spray 0·05% | Dieldrin spray 0·05% | DDT spray 0·1% | DDT spray 0·1% |
| 24. xi. 53 | Dieldrin spray 0·05% | Dieldrin spray 0·05% | DDT spray 0·1% | DDT spray 0·1% |
| 1. xii. 53 | Dieldrin spray 0·05% | Dieldrin spray 0·05% | DDT spray 0·1% | DDT spray 0·1% |
| 22. xii. 53 | Dieldrin spray 0·05% | Dieldrin spray 0·05% | DDT spray 0·1% | DDT spray 0·1% |

**Table 13**

YIELDS AND APPRAISED VALUES

(*Yield Trial, Claredale*, 1953)

| Programme | Cured Leaf: Mean Yield (lb/ac) | Cured Leaf: Appraised Value (£/ac) |
|---|---|---|
| 1 .. .. .. | 1523 | 781 |
| 2 .. .. .. | 1549 | 788 |
| 3 .. .. .. | 1576 | 784 |
| 4 .. .. .. | 1475 | 746 |
| Untreated .. .. | (276) | (117) |
| Necessary differences for significance 5% | 150 | 61 |
| Necessary differences for significance 1% | 208 | 85 |

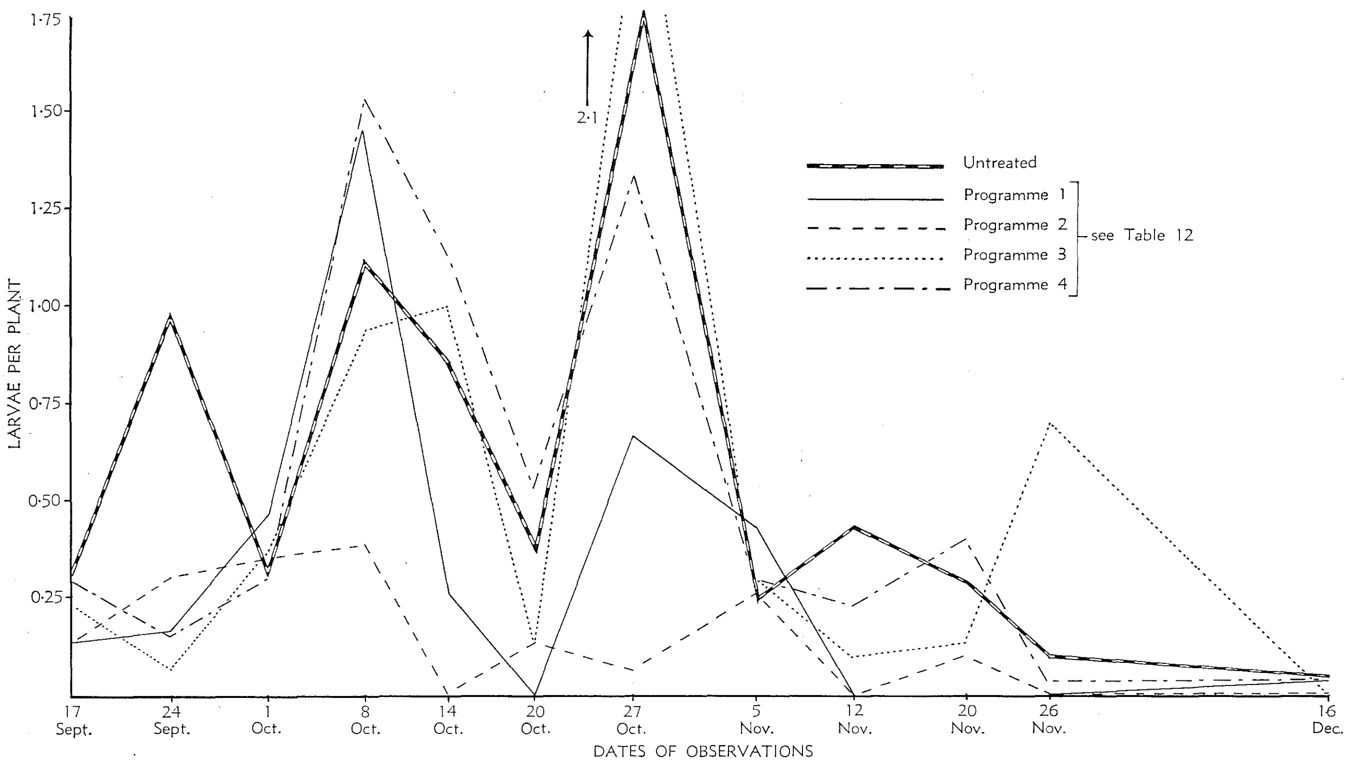


Fig. 1.—Yield trial, 1953. Suppression of *Plusia argentifera*. Dieldrin (Programmes 1 and 2) was more efficacious than DDT (Programmes 3 and 4).

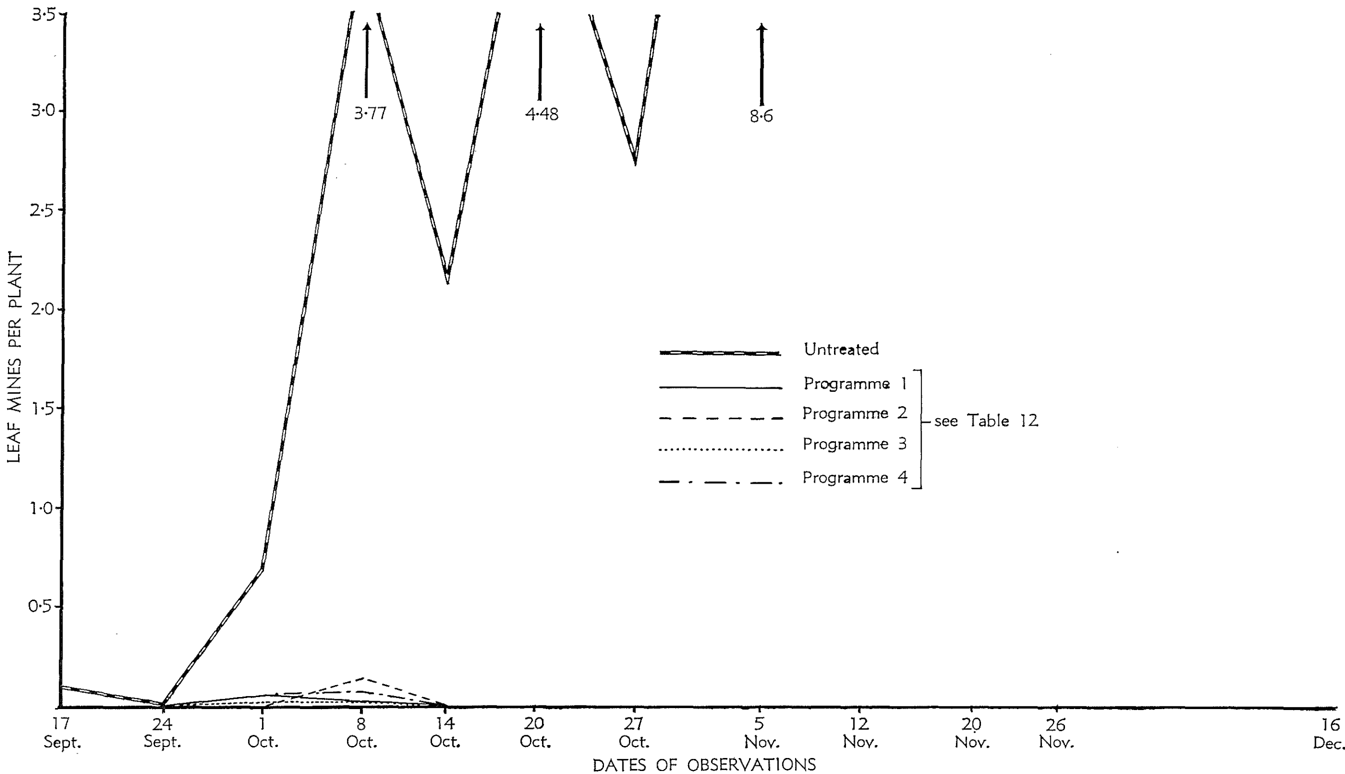


Fig. 2.—Yield trial, 1953. Suppression of *Gnorimoschema operculella.* All programmes were efficacious.

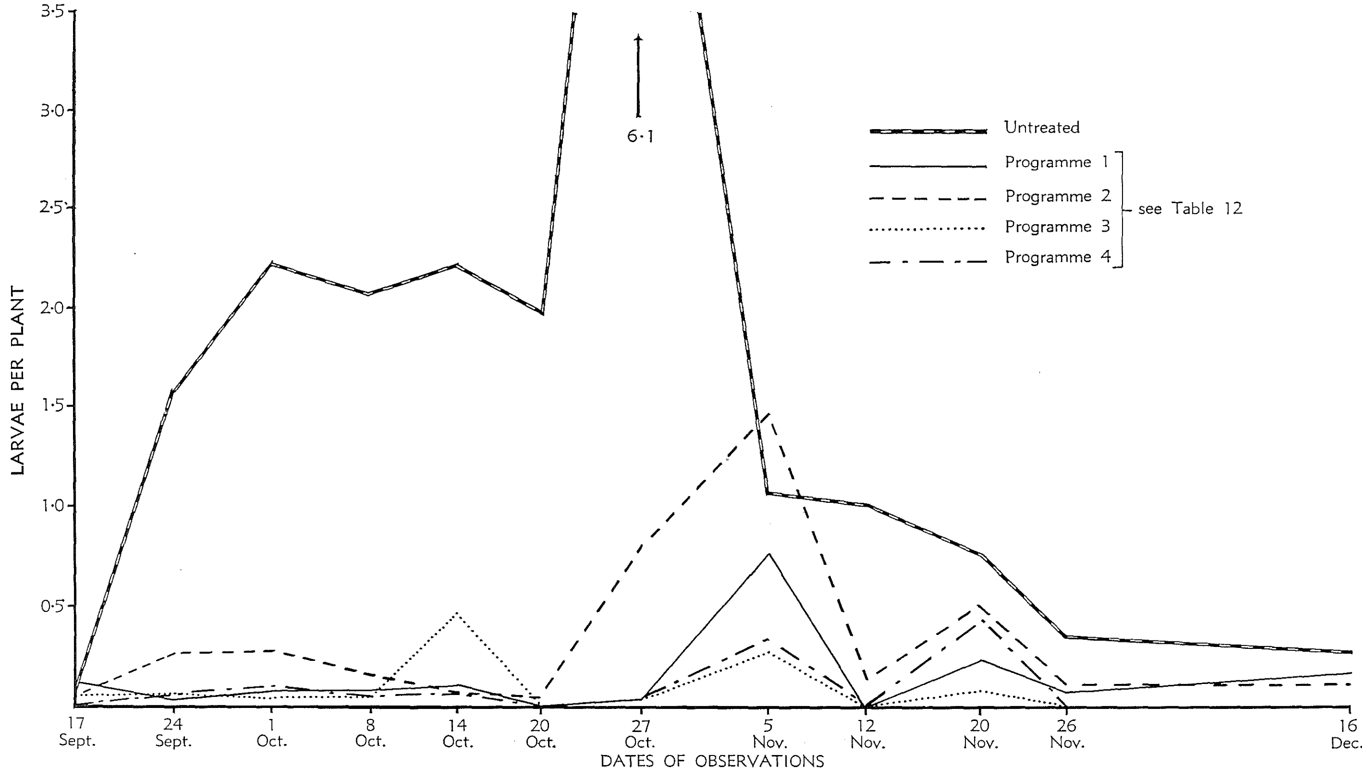


Fig. 3.—Yield trial, 1953. Suppression of *Heliothis* species. DDT (Programmes 3 and 4) was more efficacious than dieldrin (Programmes 1 and 2).

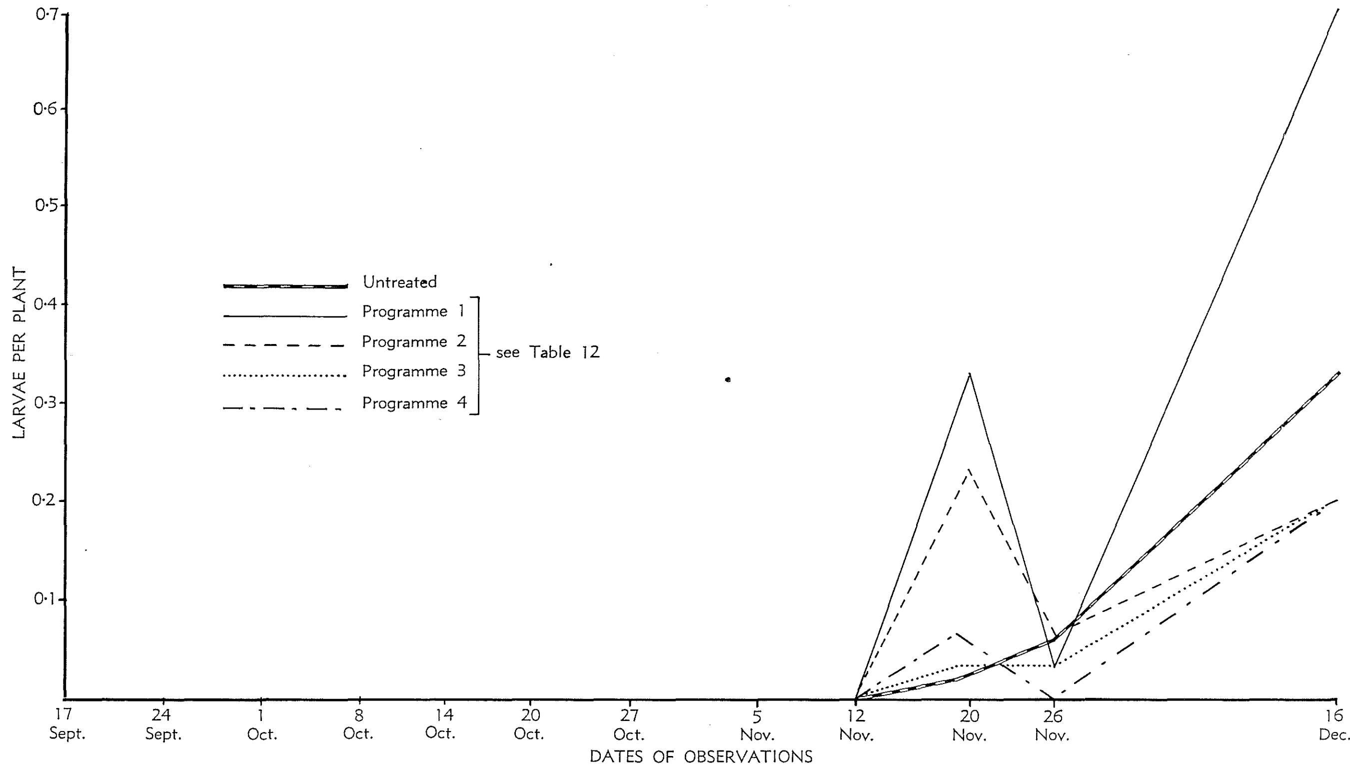


Fig. 4.—Yield trial, 1953. Suppression of *Prodenia litura.* DDT (Programmes 3 and 4) was more efficacious than dieldrin (Programmes 1 and 2).

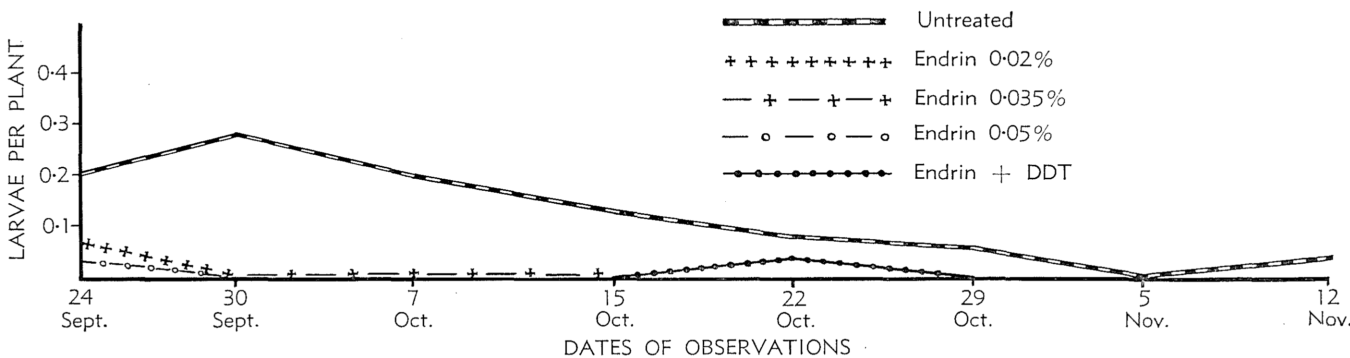


Fig. 5.—Yield trial, 1954. Suppression of *Plusia argentifera.*

**(vii) Yield Trial, 1954**

This trial was begun at Claredale in September 1954, and terminated prematurely in November when storms destroyed a high percentage of plants previously weakened by blue mould disease. The layout was a 4 x 6 randomized block with control strips. Treatment plots were 6 rows x 35 ft with a data area of 4 rows x 33¼ ft (0·012 ac); control strips were 24 rows x 14 ft with a data area of 20 rows x 12¼ ft (0·023 ac).

The 4 treatments were endrin aromatic (low range) emulsion at 0·02, 0·035 and 0·05 per cent. levels and the 0·02 per cent. level plus DDT toluol emulsion 0·1 per cent. All plots were sprayed on September 16, September 24, September 30, October 8, October 22, November 1 and November 11. Results of pest counts during the treatment period are presented in Figures 5-7.

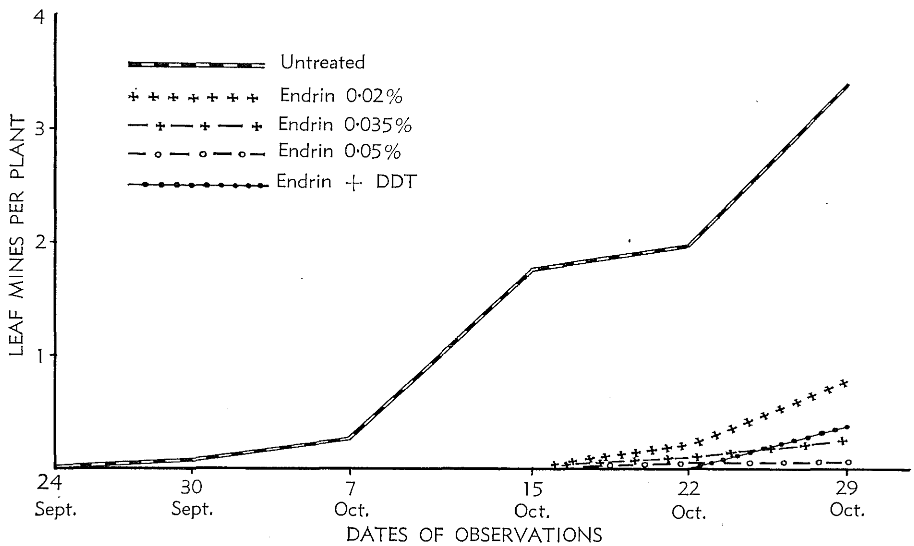


Fig. 6.—Yield trial, 1954. Suppression of *Gnorimoschema operculella*.

With small pest populations endrin effectively controlled the tobacco looper. It was inferior to DDT for control of *Heliothis* species but equal to it in controlling leaf-miner.

## (c) Discussion

The screening of numerous insecticides against the tobacco looper and their testing on a field scale against the pest complex of tobacco permitted periodic recommendations of efficacious materials. When dieldrin, and later endrin, became available these proved outstanding in percentage kill and persistence. *Heliothis* species were not controlled well enough by dieldrin or endrin and the value of retaining DDT for that purpose was demonstrated by trial results. Under the conditions of the trials all three materials were effective protective sprays against leaf-miner.

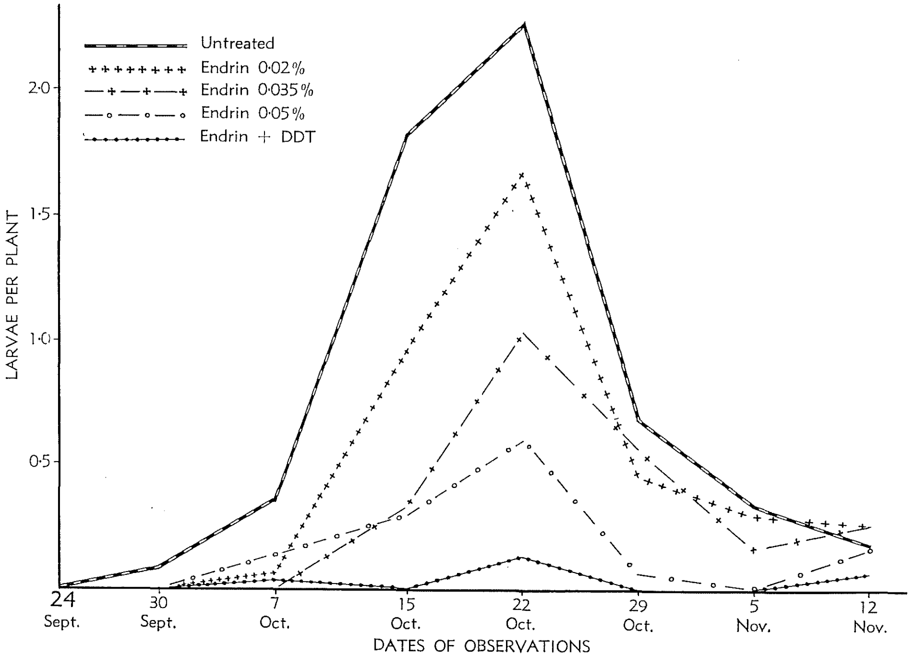


Fig. 7.—Yield trial, 1954. Suppression of *Heliothis* species.

The shortcomings of dusts and the failure of insecticides with short residual life under conditions of increasing pest populations in this work resolved doubts on a number of insecticides and formulations.

## IV. TAINTING OF LEAF

Materials of possible commercial value were taken through taint tests during 1952-1954.

### (a) Methods

Insecticides at commercial strengths and rates were sprayed by knapsack on plants in the field. Numbered samples of the cured leaf, 3 lb in weight where possible, were separately wrapped in "Cellophane" and submitted to a panel of trade assessors, which reported on any taints associated with each number. From these reports the results of each trial were prepared from the keys held.

### (b) Results

#### (i) Taint Trial, 1952

Plants at Claredale were sprayed once during January and harvested a week later. Nine samples of cured leaf were prepared from each unreplicated treatment plot. The results are presented in Table 14.

**Table 14**

TAINT TRIAL, CLAREDALE, 1952

| Treatment | No. of Samples | | |
|---|---|---|---|
| | Distinctly Tainted | Slightly Tainted | Not Tainted |
| Toxaphene 60% emulsion 0·1% .. | 4 | 0 | 4 |
| Chlordane emulsion 0·1% .. .. | 8 | 0 | 1 |
| Dieldrin 16% emulsion 0·05% .. .. | 0 | 1 | 8 |
| BHC emulsion 0·03% with other isomers | 8 | 0 | 1 |
| Aldrin emulsion 0·1% .. .. .. | 0 | 1 | 8 |
| Untreated .. .. .. .. | 0 | 0 | 9 |

One late spraying with chlordane, BHC mixed isomers or toxaphene was sufficient to taint the cured leaf.

### (ii) Taint Trial, Tiaro, 1953

Leaf was sprayed once and harvested a week later at Tiaro during January. The field layout was a 12 by 3 randomized block with one 1 lb sample taken from each plot. Results are presented in Table 15.

**Table 15**

TAINT TRIAL, TIARO, 1953

| Treatment | No. of Samples | | |
|---|---|---|---|
| | Distinctly Tainted | Slightly Tainted | Not Tainted |
| Dieldrin 16% emulsion 0·05% .. .. | 0 | 4 | 2 |
| BHC 14% emulsion 0·03% .. .. | 0 | 3 | 0 |
| BHC emulsion 0·03% with other isomers | 3 | 0 | 0 |
| Toxaphene 100% emulsion 0·1% .. | 3 | 0 | 0 |
| Aldrin emulsion 0·1% .. .. .. | 0 | 3 | 0 |
| Chlordane emulsion 0·1% .. .. | 0 | 3 | 0 |
| Endrin 18·5% emulsion 0·1% .. .. | 1 | 2 | 0 |
| Parathion 25% emulsion 0·01% .. | 0 | 1 | 2 |
| TTC dispersible powder 0·1% .. .. | 3 | 0 | 0 |
| DDT toluol emulsion 0·1% plus lead arsenate 3 lb / 50 gal .. .. | 0 | 3 | 0 |
| Untreated .. .. .. .. | 0 | 3 | 0 |

Careful mapping of the trial area and adjacent areas for ground irregularities yielded an explanation for the unexpected occurrence of slight, and even distinct, taints. These plots were in lowlying parts of the field and were unhealthy in appearance; root-knot nematodes were present in some. Tainting can therefore be a function of leaf quality. BHC mixed isomers, toxaphene and TTC were the only materials giving a distinct taint consistently.

### (iii) Taint Trial, Claredale, 1953

This trial at Claredale was located on tobacco grown from September 11, 1953, to January 6, 1954. The layout was a 4 x 3 randomized block with plots of 126 plants. From time of planting out plots were sprayed 14 times with the test materials only. Two samples of cured leaf were taken from each plot, representing early and late harvests. Nematode indices of plant roots after harvesting were allotted to plots using a method previously referred to (Smith 1957). Results are presented in Table 16.

**Table 16**

TAINT TRIAL, CLAREDALE, 1953

| Treatment | Harvest | No. of Samples | | | Nematode Index (Max. Infestation = 100) |
|---|---|---|---|---|---|
| | | Distinctly Tainted | Slightly Tainted | Not Tainted | |
| Endrin 18·5% emulsion 0·05% .. | Early | 0 | 2 | 1 | 62 |
| | Late | 0 | 1 | 2 | |
| BHC toluol emulsion 0·03% .. .. | Early | 2 | 1 | 0 | 54 |
| | Late | 0 | 2 | 1 | |
| Dieldrin aromatic (low range) emulsion 0·05% .. .. .. .. | Early | 0 | 1 | 2 | 52 |
| | Late | 0 | 1 | 2 | |
| DDT toluol emulsion 0·1% .. .. | Early | 0 | 3 | 0 | 58 |
| | Late | 0 | 2 | 1 | |

BHC failed to protect the plants from pests sufficiently to yield large samples of cured leaf. Distinct tainting was reported in two small samples. Leaf quality throughout was not high and this no doubt led to assessment of slight tainting.

### (iv) Taint Trial, 1954

Unreplicated plots of 200 tobacco plants were sprayed twice at Inglewood during April. Two harvests, each three days after a spray application, provided cured leaf from which 2 lb samples were taken. Results are presented in Table 17.

**Table 17**

TAINT TRIAL, INGLEWOOD, 1954

| Treatment | No. of Samples | | |
|---|---|---|---|
| | Distinctly Tainted | Slightly Tainted | Not Tainted |
| Endrin 18·5% emulsion 0·025% .. | 0 | 2 | 1 |
| Endrin 18·5% emulsion 0·05% .. | 0 | 1 | 2 |
| Dieldrin aromatic (low range) emulsion 0·05% .. .. .. .. | 0 | 1 | 2 |
| BHC emulsion 0·033% .. .. .. | 2 | 0 | 0 |
| Untreated .. .. .. .. | 1 | 2 | 0 |

Only BHC gave a consistent, distinct taint. Leaf quality in the block was affected by cyclone damage, insect damage and slow ripening during cold weather.

### (c) Discussion

Leaf classed as distinctly tainted was defined as objectionable when used alone or in blends. Slight tainting implied the presence of undesirable flavours which could be masked by blending the leaf. The evidence indicates that trace flavours introduced by insecticides could not be separated from flavours due to other factors.

In these trials the insecticides toxaphene, chlordane, BHC and TTC produced objectionable taints in cured leaf when sprayed on plants in the field close to harvesting. Endrin, dieldrin, aldrin, parathion and DDT did not cause taints separable from those due to growth and curing conditions.

Three facts apparent in this work and of value in future taint trials on tobacco are:—(1) leaf quality is an important factor in the detection of taints, and it is essential to use only first-quality crops; (2) provision should be made to ensure that 3 lb of leaf will be available for each sample; and (3) BHC as mixed isomers has emerged as a reliable standard for positive taint.

## V. PHYTOTOXICITY OF INSECTICIDES

The phytotoxicity of common formulations of DDT and dieldrin was tested in 1953.

### (a) Methods

Seedlings were grown at Claredale by standard methods and sprayed or dusted at intervals with the test materials until large enough to plant out in the field. Beds were seeded on September 28 and treated on October 25, October 31 and November 7. The layout was a 16 x 4 randomized block with a 2 ft x 1 ft data area in each 4 ft x $1\frac{1}{4}$ ft plot. The materials were applied with a 1 pint continuous pressure hand atomizer and a small dust gun, while a 3-sided screen restricted the materials to the plot. During November 16–18 the seedlings were dug out, washed and counted, and subsequently dried for 72 hr at 140° F and weighed.

### (b) Results

Results are presented in Table 18.

### (c) Discussion

DDT in solvent naphtha caused stunting of seedlings, which recovered slowly from obvious burning by the first two applications. Solvent naphtha alone caused no damage and some other formulations of DDT caused none.

DDT dust caused basal chlorosis and stunting of leaves with "dishing" and later recovery. This is consistent with injury observed on the young growth of field plants after dusting with DDT.

The variability within the trial allows only the conclusion that no gross reduction in seedling size was produced.

**Table 18**

MEAN MOISTURE-FREE SEEDLING WEIGHT

(*Phytotoxicity Trial, Claredale*)

| Treatment | Weight/Plant (micrograms) |
|---|---|
| Solvent naphtha emulsion 1 : 200 | 301 |
| Dieldrin solvent naphtha emulsion 0·1% | 284 |
| Untreated | 277 |
| Aromatic (high range) solvent emulsion 1 : 200 | 274 |
| DDT aromatic (high range) emulsion 0·1% | 255 |
| Dieldrin dispersible powder 0·05% | 248 |
| Emulsifier 1 : 200 | 244 |
| Dieldrin dust 5% | 243 |
| DDT dispersible powder 0·1% | 225 |
| DDT benzol emulsion 0·1% | 223 |
| DDT toluol emulsion 0·1% | 222 |
| Toluol emulsion 1 : 200 | 220 |
| Dieldrin aromatic (low range) emulsion 0·05% | 215 |
| DDT solvent naphtha emulsion 0·1% | 207 |
| Benzol emulsion 1 : 200 | 202 |
| DDT dust 2% | 183 |
| Necessary differences for significance 5% | 64 |
| Necessary differences for significance 1% | 86 |

## VI. GENERAL DISCUSSION AND CONCLUSIONS

The three phases of this investigation clearly point to endrin as the best of the materials available for use on tobacco where *P. argentifera* must be controlled. Dieldrin at a greater concentration is equally satisfactory. *Heliothis* species are not readily controlled by endrin or dieldrin. Of the materials which do control these pests, DDT is the most satisfactory.

DDT, endrin and dieldrin as protective sprays were effective in controlling leaf miner. Many other insecticides have limitations for use in tobacco pest control due to their short residual life, hazardous nature or tendency to cause tainting of the cured leaf.

On the basis of this work, recommendations for the control of tobacco pests in Queensland were published as the work proceeded, taking final form in an extension article by Smith (1955).

## VII. ACKNOWLEDGEMENTS

Facilities for conducting the trials were provided by the Agriculture Branch of the Department of Agriculture and Stock. Dr. B. R. Champ, Mr. M. Bengston and Mr. G. W. Saunders, (Entomologists) were associated with some of the trials. The British-Australian Tobacco Company reported on samples submitted to taint tests. Mr. P. B. McGovern (Senior Biometrician in the Department) carried out all statistical analyses. All this assistance is gratefully acknowledged.


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(Received for publication November 2, 1960)