DEPARTMENT OF AGRICULTURE AND FISHERIES, SOUTH AUSTRALIA

Agronomy Branch Report

ALTERNATIVES TO DDT FOR THE CONTROL OF PEA WEEVIL, *BRUCHUS PISORUM*, (L) IN FIELD PEAS

FIELD TRIALS, NORTHFIELD 1970, 1971

Y.P. LIM

Report No. NO. 94

SUMMARY

In trials conducted at Northfield in 1970 and 1971 a range of insecticides were screened as possible alternatives to DDT for pea weevil control. The best economic treatment found was endosulfan at 0.35 kg ai/ha and indications are that lower rates may be effective. As a result, DDT is no longer recommended by the Department of Agriculture and Fisheries, South Australia, for use in pea weevil control.

INTRODUCTION

The pea weevil *Bruchus pisorum*, L., an important pest of peas in all pea growing countries, became established in South Australia since 1964.

Adult beetles hibernate in winter and emerge in spring when temperatures reach 20°C to infest pea crops. Initially beetles feed on pollen. Four days after feeding on pollen, female beetles lay eggs on developing pea pods. Eggs hatch in about two weeks and larvae bore directly into the pods. After feeding for a short time near the surface of peas, they enter the centres to feed more extensively. Pupation occurs in about 40 days after an emergence hole is prepared. Adult beetles emerge 8 days to 4 weeks later. These may remain within peas until the following spring or they may emerge soon after becoming adults. Emergence is stimulated by disturbance, for example when peas are harvested or when pods shatter. Emerged beetles shelter in cracks and crevices, in posts, under bark and litter and hibernate requiring neither food nor water during this period.

Control measures include quarantine, sowing clean seed, fumigating infested produce and destroying crop residues as soon as possible after harvest. Insecticidal spray programmes are aimed at the adult insect before eggs are laid.

In 1965 Departmental trials with DDT, maldison endosulfan and "bidrin" showed that DDT at 1 kg ai/ha or endosulfan at 0.49 kg/ha gave satisfactory control. With concern over the use of DDT it is necessary to seek alternative insecticides for pea weevil control.

A wide range of organo-phosphorus insecticides are available. To obtain information on the effectiveness of these insecticides, field trials were conducted in 1970 and 1971.

This paper reports two trials:

(a) An initial screening trial at Northfield in 1970 where 12 insecticides were compared.

(b) A second screening trial at Northfield in 1971 where four promising insecticides in seven treatments were compared to DDT.

1970 Trial, Northfield

AIM

To assess whether endosulfan, naled, carbaryl, chlorfenvinphos, diazinon, chlorpyrifos, fenitrothion, methidathion, methomyl, methoxychlor and "Bayer 6010" can be used to control pea weevil in field peas.

METHODS

(a) Treatments

No.	Insecticide and Rate (kg ai/ha)		Product	Formulation	Litres/ha
1.	DDT	1.05	DDT	25% E.C.	4.21
2.	Endosulfan	0.49	"Thiodan"	35% E.C.	1.47
3.	Endosulfan	0.38	"Thiodan"	35% E.C.	1.05
4.	Naled	1.08	"Dibrom"	96% E.C.	1.12
5.	Carbaryl	1.05	"Septene"	50% E.C.	2.11
6.	Chlorfenvinphos	0.28	"Birlane"	50% E.C.	0.56
7.	Diazinon	0.89	"Gesapon"	80% E.C.	1.12
8.	Chlorpyrifos	0.60	"Dursban"	48% E.C.	1.26
9.	Fenitrothion	1.05	"Accothion"	50% E.C.	2.11
10.	Methidathion	0.56	"Ultracide"	40% E.C.	1.47
11.	Methomyl	0.56	"Lannate"	90% W.P.	0.62
12.	Methoxychlor	2.02	"Marlate"	24% E.C.	8.42
13.	"Bayer 6010"	0.70	"Bayer 6010"	25% E.C.	2.80
14.	Nil	-	-	-	-

(b) Site and Crop History

A crop of "Early Dun" field peas was grown at Northfield Research Laboratories. Crop history is as follows:

25/5/70 - 2.8 l/ha diallate applied as pre-emergent herbicide

29/5/70 - Peas sown at 100 kg/ha with superphosphate at 180 kg/ha

19/6/70 - Germinating peas treated with phosmet at 0.05 kg/ha

June/July Rains caused loss in some areas from waterlogging

14/7/70 - Crop sprayed with 5.62 l/ha dinoseb for broadleaf weed control

7/9/70 - Flowering commenced.

(c) Design

Randomised block. Three replicates of 14 treatments. Each plot divided into five sections for stratified random sampling. Size of plots 4 m x 18 m.

(d) Application

Insecticide treatments applied with 4 metre boom spray delivering 100 l/ha. Insecticides mixed in 25 l lots. Sprayer allowed to run for a short while before application to treatment plots. Excess made up insecticide was drained and sprayer completely flushed between treatments using different insecticides. Treatments applied on 6 October, 1970.

(e) Sampling

Adult beetles were sampled with a 36 cm diameter sweepnet mounted on a one-metre handle. Sweeps were made through an arc of about 160° and beetles captured counted and immediately released. Five sweeps constituting one sample were made in each section of each plot. Pre-spray count was on 1 October, 1970 and post-spray count on 9 October, 1970, three days after spray.

Egg numbers were assessed by counting total numbers of eggs on ten pods, being the five lowest pods on two plants randomly selected in each section by casting a stake. Egg counts were made on 21 October, 1970, 15 days after spray.

Damaged peas were assessed by taking a random 100 pods from the lower parts of the crop from each section of each plot, not more than 5 pods being taken from any one vine. Samples were taken from 25 November, 1970, to 27 November, 1970 and shelling done over a week. Total weights and numbers of peas in each sample were measured from 2nd December, 1970 to 8th December, 1970. The samples were then placed in paper bags and stored. Infested peas were determined by examining every pea individually for "sting" marks. To lessen the total number of peas to be so examined, infested peas were placed in a brine solution (300 g NaCl + 200 g $MgSO_4 7H_2O$ per litre). All floated peas were infested. Only the unfloated peas then had to be examined for "sting" marks. Sorting by visual examination was carried out from January 1971 to 8 February, 1971. From 5 February, 1971 it was found that more infested peas could be floated off as weevils had developed further. On 8 February, 1971, two whole samples totalling 625 peas were sorted by visual examination as well as floatation. All peas were then individually split to determine the actual number infested. The following results were obtained:

Sample No.	Total No. of Peas	No. infested determined by		
		Splitting	Visual-sort	Floatation
2.10.2	306	95	82	98
2.10.1	319	137	132	137
Total	625	232	214	235
Percentage infested		37.1	34.2	37.6

As the error made by floatation was smaller than the error made by visual sorting at this stage, remaining samples were sorted by floatation. All samples in replicate 3 and samples from treatments 8, 9, 11, 12 and 14 in replicate 2 were sorted by visual examination. All samples in replicate 1 and samples from treatments 1, 2, 3, 4, 5, 6, 7, 10 and 13 in replicate 2 were sorted by floatation. Infested peas were discarded after sorting. Uninfested peas from visually sorted samples were counted and weighed immediately after sorting. Those from floatation sorted samples were washed and air dried for five days before counting and weighing.

Harvesting machinery was not available at the appropriate time and yield samples were not taken until 18 December, 1970. By this time many of the peas had shattered and the crop had been visited by flocks of pigeons. To prevent further loss, on 18 December, 1970, 24 December, 1970 and 28 December, 1970, yield samples were hand-sieved and winnowed. Earth clods, pea sized and larger were washed out with running water, the peas were then air dried in hessian bags for 10 days before weighing.

(f) Analysis

For Analysis, counts of adult beetles and eggs were transformed to log e $(x + 1)$ where x is the original count. Derived variates were percentage infested peas by numbers and percentage infested peas by weight. Yield measurements were analysed without transformation.

RESULTS

Table 1 shows a summary of the various assessments. Detailed results of assessments are at Appendix 1.

Table 1 Summary of Assessments, 1970 Trial

Treatment and Rate			Total beetles in 75 sweeps		Total No. Eggs on 150 pods	% Infestation		Yield kg/ha
No.	Insecticide	kg ai/ha	Pre-spray	Post spray		By No.	By Wt.	
1.	DDT	1.05	7	12	183	32.9	31.8	1 201
2.	Endosulfan	0.49	4	3	102	21.4	19.1	813
3.	Endosulfan	0.38	18	7	102	25.2	23.4	818
4.	Naled	1.08	22	7	173	29.8	28.6	915
5.	Carbaryl	1.05	9	5	137	20.6	18.9	906
6.	Chlorfenvinphos	0.28	11	22	222	30.5	29.9	875
7.	Diazinon	0.89	5	4	81	25.9	24.2	1 210
8.	Chlorpyrifos	0.60	10	4	94	28.0	27.9	922
9.	Fenitrothion	1.05	13	2	52	20.5	19.0	1 002
10.	Methidathion	0.56	14	6	217	37.4	36.5	992
11.	Methiomyl	0.56	21	9	218	47.0	45.4	978
12.	Methoxychlor	2.02	8	6	158	27.8	26.7	948
13.	Bayer 6010	0.70	14	2	48	21.8	21.0	752
14.	Nil	-	18	33	359	40.5	40.3	822

Analysis of variance showed there were no significant differences between treatments for pre and post-spray adult beetle counts, percentage infestations by weight or numbers and yield assessments. There were significant differences in egg numbers at $p = 0.05$.

Table 2 summarises the result of the analysis of variance on egg numbers.

Table 2 Means of egg numbers

Treatment and Rate		Mean No. eggs per sample
Insecticide	kg ai/ha	
DDT	1.05	6.1 (1.96)
Endosulfan	0.49	2.7 (1.31)
Endosulfan	0.38	3.1 (1.42)
Naled	1.08	6.9 (2.07)
Carbaryl	1.05	3.7 (1.54)
Chlorfenvinphos	0.28	7.1 (2.09)
Diazinon	0.89	2.9 (1.37)
Chlorpyrifos	0.60	3.4 (1.49)
Fenitrothion	1.05	1.5 (0.92)
Methidathion	0.56	9.0 (2.30)
Methomyl	0.56	6.3 (1.69)
Methoxychlor	2.02	6.3 (1.98)
Bayer 6010	0.70	1.3 (0.81)
Nil	-	16.1 (2.84)
L.S.D.		
p = 0.2		(0.68)
p = 0.1		(0.89)
p = 0.05		(1.07)

*Means of transformed data log e $(x + 1)$ where x = number of eggs per sample of 10 pods.

DISCUSSION

At Northfield the crop commenced flowering from 7 September, 1970 but weather conditions were not suitable for weevil infestations until the end of September when two warm days brought weevils out. Pre-spray sampling was carried out on 1 October, 1970. Spraying was not carried out until 6 October, 1970 due to breakdown of the spraying unit on 2 October 1970 and parts were not obtained until 6 October, 1970, the following Monday. The weather was suitable for further infestations after spraying so that total numbers within the crops increased. As weevils fly into the crop from surrounding areas reinfestation of the crop was random. This resulted in highly variable post-spray counts (see Appendix 1b) although the totals (Table 1) show that increase in nil treatment plots were higher than in treated plots. This shows that most of the insecticide treatments did reduce beetle numbers present during spraying. Although analysis of variance showed that differences were not significant, total counts indicate that "Bayer 6010", fenitrothion and endosulfan are promising treatments and better than DDT.

Egg counts which were significantly different at p = 0.05 showed that best treatments were Bayer 6010, fenitrothion, endosulfan,

diazinon in that order. The two rates of endosulfan used were not different from each other.

Although there were no significant differences between treatments on percentage infestation of peas, the results indicate that good treatments were fenitrothion, Bayer 6010, endosulfan, diazinon and carbomyl.

Yield samples were extremely variable and it is possible that the flail mower may not be suitable as a method of sampling.

CONCLUSIONS

This trial shows that most promising alternatives to DDT for the control of pea weevil in field peas are Bayer 6010, fenitrothion, endosulfan and diazinon. Endosulfan tested at two rates were effective and it may be possible to lower the rate of application further.

RECOMMENDATIONS

(1) In the next trial, Bayer 6010, fenitrothion at two rates, endosulfan at three rates and diazinon should be tested and compared to DDT.

(2) As the assessments of percentage infestation made by weight and numbers were two measurements made from one sample and as these two measurements were very closely related, only one should be done in future trials, no further advantage or information being obtained by taking the two separate measurements. The biometrician has also recommended that a fixed number of peas be taken as a sample so that analysis will be conducted on a measured variate rather than a derived variate.

(3) As it has been shown that floatation of infested peas is more accurate than sorting by visual examination, future samples of infested peas should be sorted by floatation.

(4) The drastic method of sampling with a flain mower is not very suitable and in future trials attempts should be made to use harvesting machinery to collect yield samples.

1971 Trial

AIMS

(1) To assess whether endosulfan, effective at 0.42 kg ai/ha can be reduced to 0.21 kg/ha for control of pea weevil.

(2) To test whether fenitrothion, diazinon and Bayer 6010 can be used at more economic rates for control of pea weevils.

(3) To compare the above treatments with DDT used at standard rates.

METHODS

(a) Treatments

No.	Insecticide	Rate kg ai/ha	Product	Formulation	Litres/ha
1.	Endosulfan	0.35	"Thiodan"	35% E.C.	1.0
2.	Endosulfan	0.28	"Thiodan"	35% E.C.	0.8
3.	Endosulfan	0.21	"Thiodan"	35% E.C.	0.6
4.	Diazinon	0.64	"Gesapon"	80% E.C.	0.8
5.	Fenitrothion	0.50	"Accothion"	50% E.C.	1.0
6.	Fenitrothion	0.40	"Accothion"	50% E.C.	0.8
7.	Bayer 6010	0.40	"Bayer 6010	25% E.C.	1.6
8.	DDT	1.00	DDT	25% E.C.	4.0
9.	Nil	-	-	-	-

(b) Site and Design

A crop of "Early Dun" peas was grown at Northfield. A randomised block design was used. Each treatment plot is 6 m x 25 m and divided into 5 sections for stratified random sampling. There are three replicates of nine treatments.

(c) Application

Insecticide treatments applied with 6 metre boom spray delivering 100 l/ha. Insecticides mixed in 25 l lots. Sprayer allowed to run for a short while before application to treatment plots. Excess made up insecticide was drained and sprayer completely flushed between treatments using different insecticides. Treatments applied on 6.10.71.

(d) Sampling

Adult beetles were sampled with a 38 cm diameter sweepnet mounted on a one-metre handle. Sweeps were made through an arc about 160° and beetles captured, counted and immediately released. Five sweeps were made in each section of each plot. The 25 sweeps made in each plot constitute one sample. The pre-spray count was on 5 October, 1971 and post-spray count on 12 October, 1971, six days after spray.

Egg numbers were assessed by counting eggs on twenty pods selected at random from 15 to 30 cm above ground level, within a section. The position within the section was obtained by random casting of a marking stake. Egg counts were made on 22 October, 1971, 16 days after spray.

Damaged peas were assessed by taking sample of peas and separating by floatation infested peas. The random sample of peas was obtained by gathering several armfuls of vines from the middle of each section, placing these in a wheelbarrow and freeing the peas by trampling. Shells and straw were blown away using a vacuum cleaner and a counting frame used to obtain 400 peas for each sample. Samples were taken from 30 November, 1971 to 2 December, 1971 and incubated until 27 January, 1972 at 30°C. Infested peas were then floated off in a brine solution of 300 g Na Cl + 200 g Mg $So_4 7H_2O$ per litre.

Yield samples were not taken as, again, harvesting machinery was not available and 1970 results have shown that use of a flail mower for taking samples was not worth while.

(e) Analysis

Adult beetle counts had a far from normal distribution and it was not possible to transform data to obtain a normal distribution. A non-parametric analysis was done instead with three replicates of nine treatments by the Friedman two-way analysis of variance:

Egg numbers and damaged peas were transformed into log e $x + \frac{1}{2}$ for analysis.

RESULTS

Table 3 shows a summary of the assessments. Detailed assessments are at Appendix 2.

Table 3 Summary of Assessment, 1971 trial

Treatment and Rate			Total beetles in 75 sweeps		Total No. eggs on 300 pods	No. of infested peas in 6000
No.	Insecticide	kg ai/ha	Prespray	Postspray		
1.	Endosulfan	0.35	65	1	323	1 856
2.	Endosulfan	0.28	77	3	209	1 351
3.	Endosulfan	0.21	55	7	221	1 735
4.	Diazinon	0.64	52	10	587	1 887
5.	Fenitrothion	0.50	69	4	509	2 050
6.	Fenitrothion	0.40	46	30	738	2 091
7.	Bayer 6010	0.40	55	2	443	1 617
8.	DDT	1.00	47	6	732	1 985
9.	Nil	-	49	29	993	2 662

The Friedman two-way analysis of beetle counts gave the following chi^2 values:

	x^2_8	Probability		
Prespray	4.02	.80	p	.90
Postspray	11.33	.10	p	.20

Based on a calculated mean for all pre-spray beetle counts. Table 4 shows the percentage survival and percentage control in all treatments calculated according to Abbott's formula (1925).

Table 4 Percentage Survival and Percentage Control of Adult Beetles After Spray

Treatment and Rate			Percentage survival	Percentage control
No.	Insecticide	kg ai/ha		
1.	Endosulfan	0.35	1.6	96.9
2.	Endosulfan	0.28	14.1	72.2
3.	Endosulfan	0.21	10.5	79.3
4.	Diazinon	0.64	17.3	65.9
5.	Fenitrothion	0.50	6.8	86.6
6.	Fenitrothion	0.40	52.4	-3.1
7.	Bayer 6010	0.40	1.9	96.3
8.	DDT	1.00	10.5	79.3
9.	Nil	-	50.8	0

Analysis of variance showed significant differences at p = 0.05 in the egg counts. Table 5 shows the results of the analysis of variance on egg counts.

Table 5 Means of Egg Numbers

Treatment and Rate			Mean No. eggs per 20 pods
No.	Insecticide	kg ai/ha	
1.	Endosulfan	0.35	7.1 (2.03)*
2.	Endosulfan	0.28	2.6 (1.14)
3.	Endosulfan	0.21	8.2 (2.17)
4.	Diazinon	0.64	18.1 (2.92)
5.	Fenitrothion	0.50	12.0 (2.52)
6.	Fenitrothion	0.40	34.7 (3.56)
7.	Bayer 6010	0.40	4.6 (1.63)
8.	DDT	1.00	13.9 (2.68)
9.	Nil	-	63.8 (4.16)
L.S.D.			
p = 0.2			(0.97)
p = 0.1			(1.27)
p = 0.05			(1.54)

* Means of transformed data log e $(x + \frac{1}{2})$ where x = number of eggs per sample.

Infested pea numbers were significantly different at p = 0.1. Table 6 shows the result of analysis of variance on infested pea numbers.

Table 6 Mean Numbers of Infested Peas

Treatment and Rate			Mean No. of infested peas per 400	Percentage infestation
No.	Insecticide	kg ai/ha		
1.	Endosulfan	0.35	96.6 (4.57)*	24.2
2.	Endosulfan	0.28	71.0 (4.27)	17.8
3.	Endosulfan	0.21	104.7 (4.65)	26.2
4.	Diazinon	0.64	107.0 (4.68)	26.8
5.	Fenitrothion	0.50	118.3 (4.78)	29.6
6.	Fenitrothion	0.40	129.9 (4.87)	32.5
7.	Bayer 6010	0.40	86.6 (4.47)	21.7
8.	DDT	1.00	113.3 (4.73)	28.3
9.	Nil	-	172.3 (5.15)	43.1
L.S.D.				
p = 0.2			(0.34)	
p = 0.1			(0.45)	

* Means of transformed data log e $(x + \frac{1}{2})$ where x = numbers of infested peas per sample.

DISCUSSION

The results show that endosulfan is the best treatment. At 0.35 kg ai/ha, gave 97% control of adult beetles and resulted in about 7 eggs per 20 pods and 24% infestation of peas. DDT at 1 kg ai/ha gave 79% control of adult beetles and resulted in twice as many eggs in 20 pods and 28% infestation of peas. At p = 0.2 these differences were not significant. Endosulfan at the lower rate of 0.28 kg ai/ha resulted in only 2.6 eggs per 20 pods and 18% infestation of peas, the best treatment in this trial in these respects. Control of adult beetles was 72% and lower than DDT.

Bayer 6010 was another good treatment. It gave 96% control of adult beetles, resulted in 4.6 eggs per 20 pods and 22% infestation of peas. Unfortunately, the manufacturers of this insecticide have since withdrawn it from further development.

Diazinon gave poor control (66%) of adult beetles and resulted in 18.1 eggs per 20 pods and 27% infestation in peas.

Fenitrothion at 0.50 kg ai/ha gave 87% control of adult beetles. But it performed poorer than diazinon in egg counts and percentage of infested peas. The lower rate of 0.40 kg ai/ha gave no control at all in beetle numbers and was not significantly different from the nil treatment in egg counts and percentage of infested peas.

CONCLUSIONS

This trial shows that endosulfan is the best alternative to DDT for pea weevil control. Bayer 6010 which shows promise has now been withdrawn by the manufacturers. Fenitrothion and diazinon are not suitable alternatives at economic rates.

RECOMMENDATIONS

(1) The recommended rate of endosulfan used for pea weevil control can be reduced to 0.35 kg ai/ha.

(2) At this is a better treatment than DDT at 1 kg/ha, the latter recommendation can be dropped.

(3) A further trial should be carried out to elucidate the effectiveness of endosulfan at 0.28 and 0.2 kg ai/ha.

ACKNOWLEDGEMENTS

Mr. R.B. Jenkins, Mr. D. Tongh and Mr. K.R. Henry assisted at various stages in field work and laboratory sorting. Statistical analyses were carried out by the Senior Biometrician and staff, Department of Agriculture.

Appendix 1a

PRE-SPRAY COUNT OF ADULT BEETLES (1 OCTOBER, 1970)

Treatment and Rate			Replicate 1						Replicate 2						Replicate 3						Grand Total
No.	Insecticide	kg ai/ha	Section						Section						Section						
			1	2	3	4	5	Total	1	2	3	4	5	Total	1	2	3	4	5	Total	
1.	DDT	1.05	0	1	0	0	0	1	0	1	0	0	0	1	3	1	1	0	0	5	7
2.	Endosulfan	0.49	1	0	0	0	0	1	1	0	1	0	0	2	1	0	0	0	0	1	4
3.	Endosulfan	0.38	1	2	1	1	0	5	3	1	0	0	0	4	4	1	3	1	0	9	18
4.	Naled	1.08	5	1	2	0	1	9	0	0	0	0	0	0	7	2	1	2	1	13	22
5.	Carbaryl	1.05	0	0	0	0	0	0	0	0	0	0	0	0	6	1	1	0	1	9	9
6.	Chlorfenvinphos	0.28	0	2	1	0	0	3	3	0	0	0	0	3	2	1	1	0	1	5	11
7.	Diazinon	0.89	1	2	0	0	0	3	1	0	0	0	0	1	1	0	0	0	0	1	5
8.	Chlorpyrifos	0.60	0	1	0	0	0	1	2	0	3	0	1	6	2	0	1	0	0	3	10
9.	Fenitrothion	1.05	4	0	1	0	1	6	2	0	0	0	1	3	3	0	0	0	1	4	13
10.	Methidathion	0.56	7	0	0	0	0	7	1	0	0	0	0	1	1	3	0	1	1	6	14
11.	Methomyl	0.56	5	1	1	0	0	7	0	0	1	2	0	3	3	4	3	1	0	11	21
12.	Methoxychlor	2.02	0	0	1	0	0	1	1	0	0	0	0	1	3	1	2	0	0	6	8
13.	Bayer 6010	0.70	0	0	1	1	0	2	2	0	0	0	0	2	3	4	1	2	0	10	14
14.	Nil	-	3	1	2	1	0	7	1	0	0	0	1	2	4	0	0	2	3	9	18

Appendix 1b

POST-SPRAY COUNT OF ADULT BEETLES (9 OCTOBER, 1970)

Treatment and Rate			Replicate 1						Replicate 2						Replicate 3						Grand Total
No.	Insecticide	kg ai/ha	Section						Section						Section						
			1	2	3	4	5	Total	1	2	3	4	5	Total	1	2	3	4	5	Total	
1.	DDT	1.05	1	0	0	0	2	3	1	1	1	0	0	3	3	2	0	1	0	6	12
2.	Endosulfan	0.49	0	1	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0	2	3
3.	Endosulfan	0.38	1	0	1	1	0	3	0	0	0	0	1	1	1	0	0	0	2	3	7
4.	Naled	1.08	1	1	1	0	0	3	1	0	0	0	0	1	2	0	0	0	1	3	7
5.	Carbaryl	1.05	1	0	1	0	0	2	1	0	0	0	0	1	1	1	0	0	0	2	5
6.	Chlorfenvinphos	0.28	2	0	0	0	0	2	1	0	0	0	0	1	0	13	2	2	2	19	22
7.	Diazinon	0.89	0	0	0	0	0	0	0	0	1	0	0	1	1	1	1	0	0	3	4
8.	Chlorpyrifos	0.60	0	0	0	0	0	0	0	1	0	0	0	1	2	1	0	0	0	3	4
9.	Fenitrothion	1.05	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	1	2
10.	Methidathion	0.56	2	0	1	0	1	4	0	0	0	0	0	0	0	0	1	1	0	2	6
11.	Methomyl	0.56	2	2	0	0	0	4	0	0	0	0	0	0	0	1	1	2	1	5	9
12.	Methoxychlor	2.02	0	0	0	0	0	0	0	0	3	0	0	3	0	1	0	1	1	3	6
13.	Bayer 6010	0.70	0	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2
14.	Nil	-	12	1	3	1	0	17	7	0	0	2	1	10	0	4	1	1	0	6	33

Appendix 1c

POST-SPRAY COUNT OF PEA-WEEVIL EGGS (21 OCTOBER, 1970)

Treatment and Rate			Replicate 1						Replicate 2						Replicate 3						Grand Total
No.	Insecticide	kg ai/ha	Section						Section						Section						
			1	2	3	4	5	Total	1	2	3	4	5	Total	1	2	3	4	5	Total	
1.	DDT	1.05	18	3	14	0	11	46	0	5	7	0	0	12	42	24	12	25	22	125	183
2.	Endosulfan	0.49	0	1	0	4	0	5	18	0	1	1	0	20	32	10	7	22	6	77	102
3.	Endosulfan	0.38	7	17	4	0	0	28	0	4	0	0	0	4	15	20	5	10	20	70	102
4.	Naled	1.08	1	2	2	3	0	8	37	25	17	3	10	92	6	20	21	19	7	73	173
5.	Carbaryl	1.05	4	9	0	4	0	17	9	0	1	1	0	11	45	34	3	7	20	109	137
6.	Chlorfenvinphos	0.28	31	30	19	2	1	83	0	8	0	2	0	10	21	21	34	34	19	129	222
7.	Diazinon	0.89	1	0	0	5	8	14	5	2	0	0	3	10	14	14	1	13	15	57	81
8.	Chlorpyrifos	0.60	0	4	6	0	5	15	1	0	14	2	0	17	23	15	7	11	6	62	94
9.	Fenitrothion	1.05	0	0	11	0	0	11	0	7	0	0	3	10	2	6	5	18	0	31	52
10.	Methidathion	0.56	47	52	11	10	7	127	7	0	2	7	25	41	18	12	3	10	6	49	217
11.	Methomyl	0.56	67	26	5	1	0	99	2	0	0	0	0	2	6	42	4	24	41	117	218
12.	Methoxychlor	2.02	19	14	2	0	0	35	20	12	5	9	14	60	8	39	3	1	12	63	158
13.	Bayer 6010	0.70	1	1	0	0	0	2	2	0	0	0	0	2	18	10	10	6	0	44	48
14.	Nil	-	13	5	31	20	27	96	16	2	53	5	1	77	41	63	31	29	22	186	359

Appendix 1d

TOTAL NUMBER OF PEAS IN SAMPLES

Treatment and Rate			Replicate 1						Replicate 2						Replicate 3						Grand Total
No.	Insecticide	kg ai/ha	Section						Section						Section						
			1	2	3	4	5	Total	1	2	3	4	5	Total	1	2	3	4	5	Total	
1.	DDT	1.05	433	421	414	443	440	2151	343	357	358	371	400	1829	420	369	339	355	360	1843	5823
2.	Endosulfan	0.49	344	344	386	419	408	1901	327	341	323	349	367	1707	405	415	397	423	430	2070	5678
3.	Endosulfan	0.38	370	493	387	370	401	1931	332	324	338	355	449	1798	438	323	275	423	411	1970	5699
4.	Naled	1.08	324	379	368	336	373	1780	419	413	383	395	365	1975	366	342	338	374	368	1788	5543
5.	Carbaryl	1.05	328	381	387	349	355	1800	402	352	366	367	382	1869	365	345	342	307	376	1735	5404
6.	Chlorfenvinphos	0.28	327	382	381	418	367	1875	380	356	369	383	356	1844	353	358	367	351	363	1792	5511
7.	Diazinon	0.89	342	351	330	343	365	1731	358	342	356	377	429	1862	464	348	397	394	398	2037	5630
8.	Chlorpyrifos	0.60	442	408	420	414	393	2077	337	337	335	358	310	1677	374	376	332	*	367	1449**	5203**
9.	Fenitrothion	1.05	403	408	431	389	414	2045	417	429	375	419	432	2072	408	362	363	396	429	1958	6075
10.	Methidathion	0.56	428	461	413	496	357	2155	376	308	359	372	346	1761	344	347	334	388	403	1816	5732
11.	Methomyl	0.56	399	402	367	383	398	1949	364	352	375	333	345	1769	434	392	418	368	441	2053	5771
12.	Methoxychlor	2.02	373	419	431	415	409	2047	319	306	363	346	277	1611	391	380	375	353	351	1850	5508
13.	Bayer 6010	0.70	433	423	429	386	433	2104	341	374	344	329	397	1785	389	385	380	399	478	2031	5920
14.	Nil	-	373	371	339	380	386	1849	353	316	301	385	333	1688	430	410	373	401	429	2043	5580

Appendix 1e

NUMBER OF INFESTED PEAS IN SAMPLES

Treatment and Rate			Replicate 1						Replicate 2						Replicate 3						Grand Total
No.	Insecticide	kg ai/ha	Section						Section						Section						
			1	2	3	4	5	Total	1	2	3	4	5	Total	1	2	3	4	5	Total	
1.	DDT	1.05	270	226	139	179	193	1007	86	96	54	27	76	339	142	128	63	101	138	572	1918
2.	Endosulfan	0.49	35	93	51	31	37	247	84	77	45	40	67	313	136	172	157	55	134	654	1214
3.	Endosulfan	0.38	157	154	108	104	62	585	49	36	38	43	49	215	131	74	99	172	134	610	1410
4.	Naled	1.08	117	59	31	63	88	358	177	151	122	81	72	603	125	128	93	162	184	692	1653
5.	Carbaryl	1.05	76	61	39	49	28	253	36	66	30	39	17	188	210	120	92	81	170	673	1114
6.	Chlorfenvinphos	0.28	102	141	87	91	56	477	102	90	60	53	96	401	143	187	115	158	197	800	1678
7.	Diazinon	0.89	105	71	78	46	71	371	112	66	76	84	66	404	131	108	113	137	187	676	1451
8.	Chlorpyrifos	0.60	89	88	62	178	112	529	79	115	34	62	57	347	154	105	138	*	184	582**	1458**
9.	Fenitrothion	1.05	43	32	48	81	43	247	138	137	96	70	42	483	56	87	116	119	139	517	1247
10.	Methidathion	0.56	321	311	194	227	138	1191	120	57	85	61	109	432	133	103	83	92	108	519	2142
11.	Methomyl	0.56	320	168	192	194	110	984	77	98	94	22	115	406	267	255	294	214	293	1323	2713
12.	Methoxychlor	2.02	135	97	78	89	102	501	137	95	94	90	109	525	137	94	91	84	103	509	1535
13.	Bayer 6010	0.70	172	106	89	96	85	548	70	73	69	36	124	372	101	91	50	49	82	373	1293
14.	Nil	-	217	141	170	163	110	801	133	95	104	79	50	461	143	235	235	182	203	998	2260

Appendix 1f

TOTAL WEIGHTS OF PEAS IN SAMPLES (0.1 gm)

Treatment and Rate			Replicate 1						Replicate 2						Replicate 3						Grand Total
No.	Insecticide	kg ai/ha	Section						Section						Section						
			1	2	3	4	5	Total	1	2	3	4	5	Total	1	2	3	4	5	Total	
1.	DDT	1.05	895	900	914	949	1031	4689	790	792	747	790	920	4039	899	800	721	790	820	4030	12758
2.	Endosulfan	0.49	786	793	915	1000	880	4374	744	797	725	775	846	3887	890	945	860	948	987	4630	12891
3.	Endosulfan	0.38	779	841	882	870	845	4217	692	648	741	769	1071	3921	961	689	807	955	941	4353	12491
4.	Naled	1.08	685	852	822	744	840	3943	915	916	809	802	808	4250	802	697	772	851	843	3965	12158
5.	Carbaryl	1.05	657	821	856	728	762	3824	856	835	828	807	835	4161	722	733	692	626	841	3614	11599
6.	Chlorfenvinphos	0.28	704	861	845	925	777	4112	847	801	821	855	805	4129	747	760	807	774	838	3926	12167
7.	Diazinon	0.89	748	750	775	823	767	3863	833	794	806	849	969	4251	1095	791	871	879	901	4537	12651
8.	Chlorpyrifos	0.60	1038	925	927	937	794	4648	759	770	702	741	661	3633	834	835	750	*	892	3311**	11592**
9.	Fenitrothion	1.05	867	890	1002	901	982	4642	936	990	818	918	1014	4676	902	792	796	820	954	4264	12539
10.	Methidathion	0.56	941	1007	856	1052	800	4656	838	695	847	736	801	3917	744	752	665	814	970	3945	12518
11.	Methomyl	0.56	809	925	792	818	925	4169	830	832	851	687	748	3948	906	797	890	761	918	4272	12389
12.	Methoxychlor	2.02	818	910	952	872	892	4444	674	616	809	714	571	3384	877	851	829	783	807	4147	11975
13.	Bayer 6010	0.70	908	924	972	852	972	4628	751	867	770	708	868	3964	826	869	822	845	1032	4394	12968
14.	Nil	-	836	810	755	838	922	4161	765	675	612	814	709	3575	948	870	812	855	926	4411	12147

Appendix 1g

WEIGHT OF INFESTED PEAS IN SAMPLES (0.1 gm)

Treatment and Rate			Replicate 1						Replicate 2						Replicate 3						Grand Total
No.	Insecticide	kg ai/ha	Section						Section						Section						
			1	2	3	4	5	Total	1	2	3	4	5	Total	1	2	3	4	5	Total	
1.	DDT	1.05	560	484	296	364	440	2144	187	204	102	47	161	701	279	272	122	213	309	1195	4040
2.	Endosulfan	0.49	56	196	98	62	61	473	188	171	90	79	153	681	206	384	322	101	299	1312	2466
3.	Endosulfan	0.38	330	316	232	236	126	1230	78	70	63	78	93	382	272	147	207	383	293	1302	2914
4.	Naled	1.08	244	123	57	135	182	741	366	307	238	160	152	1223	260	253	220	361	417	1511	3475
5.	Carbaryl	1.05	142	107	70	87	41	447	64	138	63	88	58	411	375	249	176	161	371	1332	2190
6.	Chlorfenvinphos	0.28	204	316	181	190	172	1063	224	193	124	102	212	855	306	387	251	325	449	1718	3636
7.	Diazinon	0.89	215	137	173	105	123	7753	239	142	166	174	120	841	287	242	222	305	406	1462	3056
8.	Chlorpyrifos	0.60	197	192	134	392	278	1153	173	260	63	121	113	730	331	224	308	*	435	1298*	3221**
9.	Fenitrothion	1.05	74	57	94	169	81	475	308	310	202	142	87	1049	110	181	241	234	288	1054	2578
10.	Methidathion	0.56	701	679	409	525	308	2622	258	103	182	82	238	863	277	213	153	191	249	1083	4588
11.	Methomyl	0.56	656	383	397	408	259	2103	189	179	200	35	248	851	553	503	618	430	606	2710	5664
12.	Methoxychlor	2.02	278	173	145	167	199	962	286	181	198	264	213	1142	296	213	194	164	224	1091	3195
13.	Bayer 6010	0.70	357	231	189	209	172	1158	142	157	149	65	216	729	211	195	194	84	160	844	2731
14.	Nil	-	489	311	369	368	259	1796	266	196	203	135	147	947	293	492	508	382	477	2152	4895

* Sample mislaid

** Total excluding missing sample.

Appendix 2a

PRE-SPRAY COUNT OF ADULT BEETLES (5 OCTOBER, 1971)

Treatment and Rate			Beetle Numbers			
No.	Insecticide	kg ai/ha	Replicate 1	Replicate 2	Replicate 3	Total
1.	Endosulfan	0.35	23	36	6	65
2.	Endosulfan	0.28	31	44	2	77
3.	Endosulfan	0.21	16	31	8	55
4.	Diazinon	0.64	17	34	1	52
5.	Fenitrothion	0.50	34	27	8	69
6.	Fenitrothion	0.40	27	15	4	46
7.	Bayer 6010	0.40	19	34	2	55
8.	DDT	1.00	11	28	8	47
9.	Nil	-	21	13	15	49

Appendix 2b

POST-SPRAY COUNT OF ADULT BEETLES (12 OCTOBER, 1971)

Treatment and Rate			Beetle Numbers			
No.	Insecticide	kg ai/ha	Replicate 1	Replicate 2	Replicate 3	Total
1.	Endosulfan	0.35	1	0	0	1
2.	Endosulfan	0.28	0	2	1	3
3.	Endosulfan	0.21	4	2	1	7
4.	Diazinon	0.64	3	7	0	10
5.	Fenitrothion	0.50	0	4	0	4
6.	Fenitrothion	0.40	1	28	1	30
7.	Bayer 6010	0.40	0	2	0	2
8.	DDT	1.00	0	6	0	6
9.	Nil	-	4	9	16	29