POTATO TUBER MOTH (*GNORIMOSCHEMA OPERCULELLA* (ZELL.)) INVESTIGATIONS IN SOUTHERN QUEENSLAND.

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SUMMARY.

1. Three (sometimes two) applications of 1 lb. DDT per acre at fortnightly intervals prevented infestation of tops during most of the growing period of the spring-planted crop and reduced the likelihood of tuber infestation.

2. DDT was more effective as a spray than as a dust; sprays produced increases of up to 17% in number and 43% in weight of table quality tubers.

3. Hilling reduced tuber infestation and did not retard tuber formation when applied between 12 and 14 weeks after planting. Hilling alone did not prevent tuber damage, but following DDT spraying it served as an effective barrier against tuber infestation in the preharvest period.

4. The proper integration of DDT spraying and hilling is essential for Gnorimoschema control, as each fulfils a separate but complementary role in ensuring the maximum production of sound tubers.

INTRODUCTION.

The potato tuber moth (*Gnorimoschema operculella* (Zell.)) has long been recognized as one of the major pests of potatoes, being well established in many countries throughout the world. Larval tunnelling in the leaves (Fig. 1) and growing points reduces effective leaf area (Fig. 2), while tunnelling within the tubers reduces market value. It is by far the most important pest of potatoes in Queensland, occurring in all centres of production. In the southern part of the State, damage to tops sometimes occurs in the autumn-planted crop, but the pest rarely assumes major importance. In the spring-planted crop, however, high populations may develop, particularly during seasons of low rainfall, when total crop failures due to tuber moth attack are not uncommon.

Early attempts to control this pest with chemicals were handicapped by lack of effective insecticides and machinery for their application and by the excessive costs involved. Spray schedules incorporating arsenate of lead (Newman and Morgan, 1937) and other arsenical preparations (Lloyd, 1943 ; Helson, 1944) were unsuccessful. More promising results were obtained with derris (Lloyd, 1943) and phenothiazine (Helson, 1944) under experimental conditions, but costs of application limited their adoption on a field scale. For this reason emphasis was placed on cultural practices that would prevent or minimize damage in the field. Langford (1933) and Lloyd (1943) had found that deep planting combined with hilling as the crop developed were effective in reducing tuber infestation.

Measures applied prior to harvest gave indifferent results and additional practices were adopted to prevent further losses. Newman and Morgan (1937), Lloyd (1944) and others advocated rapid harvesting and the removal of the bagged tubers from the field as soon as practicable to reduce the likelihood of egglaying or infestation by migrant larvae once the tubers were exposed. More recently, the application of various types of insecticidal dusts to the bagged tubers has been shown to assist greatly in preventing infestation at this stage (Lloyd, 1944 ; Smith, 1944 ; Cannon, 1947 ; Helson, 1949).

With the advent of DDT, the outlook for tuber moth control in the tops changed considerably. Granovsky (1944), in preliminary trials, showed the worth of this insecticide against potato pests, while Cannon and Caldwell (1946) were able to prevent leaf mining in tobacco by *Gnorimoschema* larvae following DDT applications. Lloyd (1946), Cannon (1948), Helson (1949), and Hofmaster (1949) investigated the use of DDT to prevent damage to potato tops ; all concluded that this insecticide was superior to all other materials previously used and advocated its use in the general control programme. Though a schedule of DDT applications was shown to prevent top damage, complete tuber protection in the field was not always obtained. Both Cannon and Hofmaster considered that a schedule of DDT applications to the tops, followed by a system of hilling or ridging plants as tubers developed, would be required for effective tuber protection.

No work had been undertaken to evolve an effective schedule of DDT treatments and cultural measures of control wholly suited to the conditions pertaining in southern Queensland. Here, the pest is active soon after plants of the spring crop are through the ground in early August, and subsequent crop development occurs during a period favourable for pest development. Very high populations may be present as the crop reaches maturity.

To minimize crop damage, an effective control programme is required. To this end, experiments were carried out on the spring crop for three consecutive years, commencing in 1948. Broadly, these investigations sought information on the part played by both chemical and cultural treatments in ensuring the production of sound tubers at harvest, and any effects such treatments may have on yield of tubers.

METHODS.

All trials were planted in accordance with grower practices under irrigation conditions in the Lockyer Valley, sets being placed at a depth of 4–6 inches, in rows approximately 3 feet apart with 15-inch spacing in the rows. Cultural practices such as application of water and fertilizers, weed control and soil tillage were left to the discretion of the farmer.

Randomized layouts were used. Plot size varied slightly in different trials, according to the area of land available, the rows numbering four or five and row length being between one and two chains.

All hills were constructed with horse-drawn single-row scufflers, fitted with the appropriate attachments.

Sprays were applied by a knapsack sprayer when the plants were small, and later by a power spray fitted with a twin nozzle hand-operated spray rod operating at 200–250 lb. per square inch nozzle pressure. Dusts were applied in the early morning by manually operated rotary dusters.

It was intended to apply the insecticide at the rate of 1 lb. DDT per acre at each application. Spray dosages in the vicinity of this figure were achieved during the 1950 season's experiment, but in the two previous seasons excessive top growth necessitated applications of 100—150 gallons of 0·1% DDT spray per acre.

Dust applications ranged from 30 lb. to 45 lb. of 2% DDT dust per acre, depending on the leafiness of the plants and the atmospheric conditions prevailing. Under ideal dusting conditions, adequate plant coverage was obtained with approximately 30 lb. dust per acre. A 2% dust was used because at a lower concentration a dosage rate approaching 1 lb. DDT per acre would be wasteful of material.

1948 Experiment.

This was concerned with determining the most appropriate time for applying insecticides and the efficacy of DDT in both spray and dust forms. The trials comprised two series; in one the plots received a 2% DDT dust and in the other a 0·1% DDT spray. The series were identical in design, which was a 4 x 4 layout duplicated on two separate farms.

The treatments in both series were as follows :—

(1) DDT applied at the first sign of moth activity, with a second application 10 days later; (2) in addition to treatments in (1) above, a preharvest treatment three weeks before harvest; (3) a preharvest treatment only, three weeks before harvest; (4) no insecticides.

In both series, all plots were uniformly hilled shortly after flowering commenced and the hills maintained until harvesting. Frequent light spray irrigation was applied to reduce soil cracking as the tubers developed.

Harvesting of all plots was completed in the same week.

1949 and 1950 Experiments.

Though hilling had been practised in the 1948 season's experiment, no valid conclusions concerning its role in protecting the tubers from damage could be drawn. Subsequent experiments were concerned mainly with evaluating the relative contribution of insecticide and hilling towards freedom from tuber damage at harvest.

Abnormal rains in the spring and early summer of 1949 interfered with the trials, which were therefore repeated in the spring of 1950.

In both years, three identical trials were laid down on different farms. The layout used was six randomized blocks each covering the three cultural treatments, with insecticidal treatments superimposed and randomized within each block.

The treatments were as follows :—

(*a*) *Cultural treatments* :—(1) No hilling—inter-rows scuffled only; (2) rows hilled soon after flowering; (3) rows hilled soon after flowering and again three weeks later.

(*b*) *Insecticidal treatments* :—(A) 0·1% DDT spray applied at the rate of 1 lb. DDT per acre; (B) 2% DDT dust applied at the rate of 1 lb. DDT per acre; (C) no treatment.

The initial insecticidal treatment was applied when *Gnorimoschema* adults were first noticed in the crop. Subsequent applications were timed to prevent an infestation developing in treated plots and were made at intervals of approximately two weeks.

Assessing Results.

Estimates of pest activity within plots were made in the 1948 and 1949 seasons by counting the number of larval mines in a random sample of plants in each plot. Systematic sampling was not attempted during these two seasons.

In the 1950 experiment, a count of the number of larval mines in the terminals of a random sample of 20 plants from the inner rows of each sub-plot was made. A terminal consisted of the first six leaves below the growing point that measured not less than four inches in length. In addition, the presence or absence of larval infestation in the growing point was taken into account. At each sampling, a total of 360 terminals was counted for each treatment. Counts were made prior to each insecticidal application, with an additional count approximately 10 days before harvesting.

As each plot or sub-plot in the 1949 and 1950 experiments was harvested, the weight of tops from a sample of plants was recorded and the tubers from these plants sorted into the following grades :—

First grade :	tubers weighing three ounces or more.
Second grade :	tubers of table quality less than three ounces weight.
Chats :	all tubers too small for table use.

For each of the above grades, the number and weight of tubers and the number of tubers infested by tuber moth larvae were recorded.

The methods of taking plant samples were as follows :—

1948 experiment : Twenty consecutive plants from each of two inner rows per plot were sampled, a total of 320 plants per treatment.

1949 experiment : Ten consecutive plants from each of two inner rows of each sub-plot were sampled, giving a total of 360 plants per treatment.

1950 experiment : Five consecutive plants comprised a unit sample. Three such samples were taken from sections of the inner rows in each sub-plot, making a total of 54 samples (or a total of 270 plants) per treatment.

1951 Observations.

Though formal plots were not used, several commercial crops were kept under close and regular observation during the 1951 season. On these areas, insecticidal and hilling treatments conformed to a pattern suggested by the results obtained in the previous experimental studies. The worth of these treatments was assessed by observing the extent of top damage and tuber infestation at harvest.

RESULTS.

1948 Experiment—Sprayed Series.

Block A.—This trial, on portion of a commercial block of certified Factor potatoes, commenced with the application of a 0·1%DDT spray to treatments 1 and 2 on September 13. Moths were prevalent before this treatment was applied, and though plants were only six to eight inches high and possessed on the average from four to six leaves per plant, larval damage was evident. A pretreatment estimate of *Gnorimoschema* activity showed a mean of 1·4 larval leaf mines per plant.

The application of DDT to the surrounding commercial crop coincided with the initial experimental treatment and temporarily checked moth activity. Moths were again active by September 23, when the plants were approximately 12 inches high, with flower buds evident on most of them. A second DDT application was then given to plots receiving treatments 1 and 2. By this time a considerable difference between plots in rate of plant growth was evident. Plants which had received DDT applications made good top growth and were virtually devoid of insect damage. In contrast, unsprayed plants showed extensive larval mining ; populations of *Austroasca viridigrisea* Paoli and *Macrosiphum gei* Koch were also present and contributed towards a ragged appearance of the plants and obvious checking of their growth.

The preharvest DDT application for treatments 2 and 3 was applied to the respective plots on October 22. By this time, extensive leaf mining had occurred in plots receiving treatments 3 and 4 and some tops carried little green foliage. Those plants receiving treatments 1 and 2 showed little damage at this stage, the plants continuing to grow vigorously.

This trial was harvested on November 11.

Block B.—This duplicate experiment was located on a portion of an area of certified Factor potatoes on a farm some distance from the companion block A.

A pretreatment count on September 13 of larval mines from 100 plants within the experimental area gave a mean of 1·2 larval mines per plant. Subsequently, the incidence of *Gnorimoschema* developed to a greater degree than that recorded on block A. No insecticides were used in the adjacent farm area.

DDT applications in the separate treatments were made on dates corresponding with those in block A. Growth responses in those plots receiving treatments 1 and 2, and the effect of DDT on the general insect population, were again evident.

Following harvesting on November 10, the data from these two blocks were summarized (Table 1). Mean values for weight of tops and weight and number of tubers in each grade were calculated on the basis of 40 plants per plot; the figures for percentage infestation are weighted averages of the separate percentage figures. The prevention of insect damage on top growth in plots receiving treatments 1 and 2 was reflected in the increased weight and number of tubers produced. Highly significant increases of 43 per cent. in weight and 17 per cent. in number of table quality tubers were recorded.

Fig. 1.

Potato Leaves Infested by *Gnorimoschema operculella* (Zell.). At this stage the larvae may still be active within the leaves.

Table 1.

SUMMARY OF DATA—1948 EXPERIMENT (SPRAYED SERIES).

Treatment.	Mean weight of tubers. (oz.)			Mean number of tubers.			Mean weight of tops. (oz.)	Moth-infested tubers. %
	First and second grade.	Chats.	Total.	First and second grade.	Chats.	Total.		
1. Early spraying..	742	47	789	202	64	266	254	3·7
2. Early plus preharvest spraying	713	52	765	186	68	254	302	2·4
3. Preharvest spraying	493	39	532	161	57	218	193	7·3
4. Untreated ..	501	42	553	156	71	227	107	11·2
s.e.	21·6	5·7	22·0	6·6	7·0	8·5	16·9	..
Significant differences—								
5% level ..	64	17	65	20	21	25	50	2·0
1% level ..	88	23	90	27	28	35	69	2·8

A preharvest treatment only, though prolonging top growth to a slight degree, had no influence on yield. DDT applications by reducing populations in the tops decreased the likelihood of tuber infestation; early treatments were more effective than the preharvest treatment in this respect.

1948 Experiment—Dusted Series.

Block A.—This trial, using the variety Sebago, was situated on the same farm and close to the sprayed series in block A. Thus somewhat similar levels of pest population could be expected for the two experimental blocks. A pretreatment count of larval activity in the tops within the dusted series gave a mean of 1·3 larval mines per plant.

Rain showers reduced the effectiveness of the dust deposit on the plants, falls being recorded within three days of both the first and second dust applications to treatments 1 and 2 on September 11 and 25. From the outset the dust did not appear to exhibit the same degree of control as the DDT spray and some moths were always present among the plants. An examination of 30 mines on leaves of both dusted and untreated plants on September 29, following the second application of dust, showed that 13 larvae were alive on the dusted plants and 24 on the untreated.

No obvious growth differences were noticeable between plants on dusted and untreated plots by September 29—a marked contrast to the obvious effect produced in the sprayed series nearby. However, all plants were responding to good growing conditions at this time, and it was obvious that the variety Sebago was not affected by larval damage to the same extent as Factor. The Sebago plants were more upright and spreading, and the larger top growth tended to mask larval mining in the leaves.

The preharvest treatment was applied on the morning of September 23. All plots were harvested on November 12. The results, expressed as plot means, are given in Table 2.

Table 2.

DATA FOR 1948 EXPERIMENT (DUSTED SERIES).

Treatment.	Mean weight of tubers. (oz.)			Mean number of tubers.			Mean weight of tops. oz.	Moth-infested tubers. %
	First and second grade.	Chats.	Total.	First and second grade.	Chats.	Total.		
1. Early dusting ..	782	42	824	180	46	226	264	7·2
2. Early plus preharvest dusting..	687	50	737	153	49	202	294	6·5
3. Preharvest dusting	476	39	515	133	43	176	168	6·8
4. Untreated ..	551	30	581	137	34	171	155	7·6
s.e.	50·1	7·8	54·6	12·2	7·3	16·6	23·0	..
Significant differences—								
5% level ..	160	25	175	39	23	53	74	3·2
1% level ..	230	36	251	56	..	76	106	..

Block B.—This portion of the experiment, also laid down on the variety Sebago, was abandoned before harvest as unforeseen circumstances prevented uniform cultural management throughout the experimental area.

The results from block A revealed a similar trend as in the sprayed series with regard to weight and number of tubers and weight of tops produced for the several treatments. Early DDT applications resulted in increases of 42 per cent. in weight and 32 per cent. in number of tubers produced. However, variability between plots within treatments increased the necessary differences for significance. This can be attributed partly to uneven dust cover and the effect of rain in reducing the residual action of the dust.

No significant difference in percentage tuber infestation occurred between treatments. This could be explained partly by the reduced efficacy of the dust, but it is more likely due to a varietal characteristic. The varietal habit of producing long stolons increased the likelihood of the ground cracking, as the tubers tended to form nearer the soil surface; further, many tubers were partly exposed by hilling operations.

1949 Experiment.

Trials were located on three separate farms, and though some uniformity was possible in timing insecticide applications, unseasonable rainfall with resultant high soil moisture did not allow hilling to be undertaken at corresponding times on the three properties. Though interfering with the original plan of the experiment, this afforded an opportunity of evaluating the respective control measures under the abnormal conditions experienced.

Fig. 2.
Effective Leaf Area Reduced by the Larval Mining of *Gnorimoschema operculella* (Zell.).

Trial 1.

In this trial, planted in mid-July to the variety Sebago, the majority of plants were flowering and had made large top growth by October 5. Excessive rain and its effect on the heavy clay loam soil prevented cultural treatment (2) being applied until treatment (3) was due. Both hilling treatments were carried out on November 1. The experiment was harvested on November 16.

The first DDT treatments, both spray and dust, were applied on October 5. Prior to this date *Gnorimoschema* was virtually absent, and only a very light infestation was evident when treatments were applied. A second insecticidal treatment was delayed by rain for so long that it was considered too late to be of any consequence for experimental purposes.

Though moths were always present in the plots after October 5, numbers were never high and the excessive growth of the tops masked pest activity. Adults of *Epilachna 28-punctata* Fabr. were prevalent after flowering, their damage being noticeable by harvest. The differences between treatments, particularly with regard to weight of tops produced, were largely due to this pest. Other pests, including *Austroasca viridigrisea*, were of little importance. The results, expressed as sub-plot means, are presented in Table 3.

Table 3.

DATA FOR 1949 EXPERIMENT (TRIAL 1).

Insecticidal Treatments.	Cultural Treatments.				Significant Differences.
	1. No Hilling.	2. Early Hilling.	3. Late Hilling.	Means.	
	(a) Mean weight of tubers from 10 plants (oz.)				
A (DDT spray)	261	269	267	266	
B (DDT dust)	323	254	233	270	
C (Untreated)	276	254	250	260	
Means	287	259	250	265	
	(b) Mean number of tubers from 10 plants.				
A (DDT spray) ..	75	68	62	68	
B (DDT dust)	76	70	66	70	
C (Untreated)	76	70	75	74	
Means	75	70	68	71	
	(c) Mean weight of tops of 20 plants (oz.)				
A (DDT spray) ..	169	169	153	163	A ≫ B
B (DDT dust)	134	159	121	138	A > C
C (Untreated)	145	140	144	143	
Means	149	156	139	148	
	(d) Percentage tuber infestation.				
A (DDT spray) ..	6·4	2·2	3·6	4·1	(1 > 2)
B (DDT dust)	9·6	5·2	5·5	6·7	B > A
C (Untreated)	7·0	4·6	3·9	5·2	
Means	7·7	4·0	4·3	5·3	

In the final column, brackets indicate that the difference exceeds the necessary difference for significance but the F value in the analysis of variance is not significant.

> = significantly greater than at the 5% level.

≫ = significantly greater than at the 1% level.

Despite a low incidence of *Gnorimoschema* for the greater part of the experiment, hilling approximately two weeks before harvest was effective in slightly reducing percentage tuber infestation. This benefit was obtained despite the soil being too wet to permit the construction of proper hills. There is a suggestion that hilling was associated with a slight reduction in both weight and number of tubers produced, but the differences were not significant.

Insecticidal treatments were not associated with any increases in weight or number of tubers produced and were applied too early to have any influence on tuber infestation at harvest. Sprayed plots produced more top growth than dusted or untreated plots, an effect due largely to the incidence of *Epilachna 28-punctata* and allied foliage pests in the respective plots throughout October. Such damage was of little consequence, for it had no influence on the yields obtained.

Trial 2.

This area of the variety Sarenac on a heavy clay loam soil was planted in late August following late winter rains. *Gnorimoschema* was active by the beginning of October, and the first DDT treatment was applied on October 5. By this time, some plants were flowering but had not produced large tops. The second DDT treatment was delayed by rain until November 3 ; larval activity in the tops had been increasing for some time. The excessive top growth prevented good coverage being obtained. Further rains in mid-November prevented the application of a third insecticidal treatment ; there was evidence of *Gnorimoschema* activity at this time.

Recurrent rain and the constant wetness of the soil caused by excessive top growth interfered to some extent with the application of cultural treatments. The early hilling treatment was applied on October 17 when the majority of plants were flowering, but the wet, firm soil prevented the implements penetrating to a sufficient depth and these hills were poorly constructed. The late hilling treatment was applied on November 9, and again excessive soil moisture and intergrown plants prevented the formation of satisfactory hills. Maintenance of these hills was prevented by further rain.

Apart from *Gnorimoschema*, pests were of little importance. Any activity by *Epilachna 28-punctata, Austroasca* spp. and other leaf-feeding insects was masked by the copious leaf growth.

The variety Sarenac formed its tubers on unusually long stolons, some measuring over nine inches in length. Some tubers formed within the soil zone traversed by cultivating and hilling implements. No doubt hilling interfered with the setting or development of such tubers, while many were left partly exposed or only slightly covered with soil after the passage of the hilling implement. Soil packing from the heavy rains and the excessive growth of tops promoted mechanical damage to tops during hilling. This, in turn, would influence plant growth to a certain degree.

Table 4.

DATA FOR 1949 EXPERIMENT (TRIAL 2).

Insecticidal Treatments.	Cultural Treatments. 1. No Hilling.	2. Early Hilling.	3. Late Hilling.	Means.	Significant Differences.
(a) Mean weight of tubers from 20 plants (oz.)					
A (DDT spray) ..	516	436	473	475	1 » 2 ; 1 > 3
B (DDT dust)	484	390	382	419	A » C ; A > B
C (Untreated)	427	393	389	403	
Means	475	406	415	432	
(b) Mean number of tubers from 20 plants.					
A (DDT spray) ..	137	117	118	124	1 » 3 ; 1 > 2
B (DDT dust)	130	116	95	114	A » C
C (Untreated)	113	103	92	102	
Means	127	112	102	113	
(c) Mean weight of tops of 20 plants (oz.)					
A (DDT spray) ..	155	127	172	151	
B (DDT dust)	153	146	123	141	A, B » C
C (Untreated)	82	115	114	103	
Means	130	129	136	132	
(d) Percentage tuber infestation.					
A (DDT spray) ..	44·9	42·0	41·9	42·9	
B (DDT dust)	42·4	46·7	41·0	43·3	(1 > 3)
C (Untreated)	48·1	44·2	39·8	44·0	
Means	45·1	44·3	40·9	43·4	

Brackets indicate that the difference exceeds the necessary difference for significance but the F value in the analysis of variance is not significant.

> = significantly greater than at the 5% level.
» = significantly greater than at the 1% level.

Harvesting was unavoidably delayed for approximately two weeks until December 14, when extensive ground cracking was evident. *Gnorimoschema* moths were prevalent in the area and tuber infestation was severe when the experiment was eventually harvested. Table 4 sets out the results, expressed as sub-plot means.

The delay in harvesting nullified any benefits that DDT applications or hilling may have had on percentage tuber infestation. The waterlogged soil cracked extensively once the tops of the plants wilted and the surface of the soil became exposed to the sun. Under such conditions, the poorly-prepared hills could not have been expected to fulfil their true function. *Gnorimoschema* populations from untreated plots and neighbouring areas of unsprayed potatoes found conditions ideal for the rapid reinfestation of DDT treatment plots.

Late hilling probably prevented tuber infestation to a slight degree, though the difference was not significant. Significant differences in favour of late hilling were obtained for percentage infestations in first grade tubers only (Table 5), suggesting that a greater proportion of these larger tubers than of the second grade and chats is formed deeper in the soil.

Table 5.

DATA FOR 1949 EXPERIMENT (CULTURAL TREATMENTS, TRIAL 2).

—	Cultural Treatments.				Difference necessary for significance at 5% level.
	1. No Hilling.	2. Early Hilling.	3. Late Hilling.	Means.	
First grade	37·7	39·3	31·4	36·1	6·5
Second grade	51·7	47·5	47·8	49·0	7·8
Chats	52·8	49·5	52·7	51·7	10·0

Though DDT applications were never sufficient to suppress *Gnorimoschema* activity entirely, they promoted greater top development than occurred in untreated plots. This has again been reflected by an increase in both weight and number of tubers produced, the DDT spray (18 and 23 per cent. increases) being more effective in this respect than the dust (4 and 11 per cent.).

As expected from the habits of tuber formation of this variety, hilling, though somewhat more likely to cause plant damage under the soil conditions prevailing, has had a marked effect on both weight and number of tubers produced. Both early and late hilling caused a reduction of some 15 per cent. in weight of tubers produced.

Trial 3.

This trial, located on a sandy loam, was planted to the variety Factor in mid-August. *Gnorimoschema* moths were present in the area by October 5, when DDT treatments were applied. The early hilling treatment was carried out on October 11, when the majority of plants were flowering. The friable soil enabled hills to be formed satisfactorily. Before the late hilling treatment was applied on November 3, the abnormal rains promoted abnormally large tops and these hills were not completed without some difficulty and damage to plants.

Moths were again prevalent and foliage damage was evident in the area by early November, but rain delayed the application of DDT until November 15. Excessive top growth and further rains reduced the efficacy of both insecticidal and cultural treatments. Slight activity and damage by *Epilachna* were observed in early November and some plant defoliation had occurred by harvest.

Late rains and excessive soil moisture delayed harvesting until November 24, when ground cracking was evident on the better drained portions of the experimental area. The results obtained are expressed as sub-plot means in Table 6.

Table 6.

DATA FOR 1949 EXPERIMENT (TRIAL 3).

Insecticidal Treatments.	Cultural Treatments.				Significant Differences.
	1. No Hilling.	2. Early Hilling.	3. Late Hilling.	Means.	
	(a) Mean weight of tubers from 10 plants (oz.)				
A (DDT spray) ..	198	204	201	201	
B (DDT dust)	215	191	217	208	
C (Untreated)	243	196	184	208	
Means	219	197	201	205	
	(b) Mean number of tubers from 10 plants.				
A (DDT spray) ..	73	69	79	73	
B (DDT dust)	77	82	89	82	(B > A, C)
C (Untreated)	80	68	73	74	
Means	77	73	80	77	
	(c) Mean weight of tops of 20 plants (oz.)				
A (DDT spray) ..	206	134	178	173	
B (DDT dust)	159	150	138	148	
C (Untreated)	162	135	79	125	
Means	176	140	132	149	
	(d) Percentage tuber infestation (all grades).				
A (DDT spray) ..	22·5	19·2	8·4	16·7	1 ≫ 2, 3
B (DDT dust)	26·7	12·6	14·4	17·9	C > A, B
C (Untreated)	29·1	18·1	22·5	23·2	
Means	26·1	16·6	15·1	19·3	

In the last column, brackets indicate that the difference exceeds the necessary difference for significance, but the F value in the analysis of variance is not significant.

> = significantly greater than at the 5% level.

≫ = significantly greater than at the 1% level.

The interval of approximately six weeks between the two insecticide applications coincided with a period when crop development was proceeding rapidly. The early DDT application had little influence on pest populations during this period and all plots were subject to similar levels of pest activity. The late insecticide treatment, nine days prior to harvest, would not have retrieved the position and thus little benefit in top weight or tuber yields could be expected from DDT applications. The late application of DDT did reduce percentage tuber infestation by approximately 30 per cent.

Tuber infestation at harvest was far in excess of what would have been expected had DDT been applied on a closer schedule. Despite the relatively high populations of *Gnorimoschema* throughout November, both early and late hilling reduced tuber infestation by approximately 40 per cent., while a combination of late DDT spraying and late hilling was very effective in preventing tuber damage.

Hilling had no influence on tuber yield, in contrast to the finding in other experiments. The friable soil and the ease with which the hills were formed may have been partly responsible, though the habit of the variety Factor in forming the greater bulk of its tubers close to the base of the plant would preclude damage of the order associated with the long stoloned varieties, Sarenac and Sebago.

1950 Experiment.

Triplicate trials differing only in soil type and variety planted were commenced. One planted to the variety Katahdin on a heavy black clay loam became waterlogged soon after planting and was abandoned. Whereas all plots in the two previous season's experiments embraced four rows, plots in the 1950 series were increased in size to include five rows, the plants in the three inner rows furnishing the data recorded.

Trial 1.

The variety Sequoia was planted on a dark-brown sandy loam on August 9, following heavy July rains. The majority of the sets had germinated by the end of August. Flowering was well advanced by October 13 and two weeks later cultural treatment (2) was applied. The late hilling treatment was carried out on November 21, when the hills in treatment (2) plots were repaired. Further cultural attention was prevented by rain.

Very slight moth activity was noticed on September 20, and a pretreatment count of larval mines on September 29 gave a mean of 0·16 mine per terminal. DDT applications were made on September 29. A further count of larval mines on October 13 gave the following results :—Sprayed plots 0·01 mine per terminal ; dusted plots 0·02 mine per terminal and untreated plots 0·10 mine per terminal. Further DDT was applied immediately following this count to check tuber moth activity in treated plots. A third estimate of *Gnorimoschema* activity on November 3 revealed the following order of infestation in plots :—Sprayed—0·0 mine per terminal ; dusted—0·01 mine per terminal; and untreated—0·44 mine per terminal. A third and final insecticide treatment was applied following this count.

Very low populations of the two jassids *Austroasca viridigrisea* and *Orosius* (*Thamnottetix*) *argentatus* Evans were recorded in late September. Newly established colonies of the aphis *Macrosiphum gei* were prevalent at this time but these disappeared from plants receiving DDT applications. Large numbers of *Epilachna* adults appeared in the plots in early October, but these insects largely disappeared from plots after the second DDT application, though some persisted in untreated plots until harvest.

Though rain was recorded frequently throughout October and November, the plants did not produce excessive top growth. An attack of Irish blight (*Phytophthora infestans* de Bary) developed in showery weather in early November and severe plant defoliation had occurred by the end of the month. This discouraged the development of tuber moth in the tops as the plants aged, while the persistent showers throughout November prevented ground cracking as tubers developed. As a result, tubers were harvested on December 8 virtually free from *Gnorimoschema* infestation. The yield data obtained are presented in Table 7; each value represents the mean yield for a 5-plant sample, weights being given in ounces.

Table 7.

DATA FOR 1950 EXPERIMENT (TRIAL 1).

Insecticidal Treatments.	Cultural Treatments.				Significant Difference 5% level.
	1. No Hilling.	2. Early Hilling.	3. Late Hilling.	Means.	
	(a) Weight of tops.				
A (DDT spray) ..	27·3	31·6	20·7	26·5	
B (DDT dust)	24·5	25·9	26·0	25·5	A, B > C
C (Untreated)	23·9	18·2	21·9	21·4	
Means	25·2	25·2	22·9	24·4	
	(b) Number of tubers produced.				
A (DDT spray) ..	30·4	32·2	33·8	32·1	
B (DDT dust)	30·4	30·8	29·5	30·2	
C (Untreated)	31·0	30·8	31·2	31·0	
Means	30·6	31·3	31·5	31·1	
	(c) Weight of tubers.				
A (DDT spray) ..	127·6	123·9	143·1	131·5	
B (DDT dust)	128·6	127·0	127·4	127·6	A > C
C (Untreated)	123·3	119·1	117·3	119·9	
Means	126·5	123·3	129·3	126·4	

The *Gnorimoschema* damage recorded in the tops prior to harvest was too slight to influence tuber production and any differences between treatments must be considered as due to the combined effect of all pests encountered. *Epilachna*, particularly, defoliated some plants in untreated plots and its effects would largely account for any differences between treatments in weight of tops produced. DDT treated plots were noticeably more leafy than untreated plants. Any top damage would in turn be reflected in tuber yields, and, in particular, late damage would be more likely to influence weight of tubers produced without necessarily affecting the number of tubers formed. Hilling had no apparent effect on the number or weight of tubers produced.

Trial 2.

This trial, planted to the variety Sebago, was located on a dark-grey to black clay loam. Rain delayed planting until August 15.

Cultivation and irrigation were well maintained and weeds were always under control, so good even growth resulted. The early cultural treatment (2) was applied on October 25, the hills being repaired when cultural treatment (3) was applied two weeks later. All hills were fairly well maintained until harvest. The heavy soil was not entirely suited to hilling ; ground packing followed the late winter and early spring rains and the cloddy nature of the soil often prevented a uniform hill being maintained.

Table 8.

DATA FOR 1950 EXPERIMENT (TRIAL 2).

Insecticidal Treatments.	Cultural Treatments.				Significant Differences.
	1. No Hilling.	2. Early Hilling.	3. Late Hilling.	Means.	
		(*a*) *Weight of tops.*			
A (DDT spray) ..	38·6	31·9	27·7	32·7	A ≫ C
B (DDT dust)	32·4	31·7	28·0	30·7	B > C
C (Untreated)	30·6	25·1	21·3	25·7	
Means	33·9	29·5	25·7	29·7	
		(*b*) *Number of tubers.*			
A (DDT spray) ..	30·3	25·2	27·9	27·8	1, 3 > 2
B (DDT dust)	29·9	25·4	29·9	28·4	A, B > C
C (Untreated)	27·4	21·9	26·9	25·4	
Means	29·2	24·1	28·3	27·2	
		(*c*) *Weight of tubers.*			
A (DDT spray) ..	126·9	114·8	109·9	117·2	
B (DDT dust)	112·5	106·9	122·8	114·1	A > C
C (Untreated)	118·2	99·0	103·5	106·9	
Means	119·2	106·9	112·1	112·7	
		(*d*) *Percentage tuber infestation* (*all grades*).			
A (DDT spray) ..	3·3	0·5	0·3	1·1	1 ≫ 2, 3 B, C ≫ A
B (DDT dust)	15·1	0·8	3·0	4·8	with 1 : B, C ≫ A with 2 : no sig. diff.
C (Untreated)	11·6	1·9	1·3	4·0	with 3 : B ≫ A
Means	9·3	1·0	1·3	3·0	

Table 8.—*continued.*

DATA FOR 1950 EXPERIMENT (TRIAL 2).

Insecticidal Treatments.	Cultural Treatments. 1 No Hilling	2 Early Hilling.	3 Late Hilling.	Means.	Significant Differences.
	(e) Percentage tuber infestation (first grade).				
A (DDT spray)	2·6	0·1	0·8	0·9	1 ≫ 3 ; 1 > 2
					with 1 : B ≫ A
B (DDT dust)	9·8	1·0	0·1	2·2	with 2 : C >A
C (Untreated)	5·6	2·4	0·3	2·2	with 3 : no sig. diff.
Means	5·7	0·9	0·3	1·7	
	(f) Percentage tuber infestation (second grade).				
A (DDT spray) ..	2·5	1·4	0·0	0·9	1 ≫ 2, 3
					B ≫ A ; C > A
					with 1 : B, C ≫ A
B (DDT dust)	13·5	0·8	5·9	5·5	with 2 : no sig. diff.
C (Untreated)	18·6	0·4	0·5	3·7	with 3 : B ≫ A ; B > C
Means	10·3	0·8	1·1	3·0	
	(g) Percentage tuber infestation (chats).				
A (DDT spray) ..	1·2	0·0	0·0	0·1	1 ≫ 2, 3
					B, C ≫ A
B (DDT dust)	21·8	0·1	3·6	5·5	with 1 : B, C ≫ A
					with 2 : no sig. diff.
C (Untreated)	11·9	0·9	2·2	3·9	with 3 : B > A
Means	9·7	0·2	1·3	2·5	

> = significantly greater than at 5% level.
≫ = significantly greater than at 1% level.

Gnorimoschema moths were active soon after the plants appeared through the ground in late August. Little larval damage had occurred by the end of September, when a count of larval mines in 360 terminals showed a mean of 0·3 per terminal. DDT was applied to treatment plots on September 29, October 13, and November 2, immediately following counts of larval mines in the terminals. The results of these counts are presented in Fig. 3. By early November, extensive leaf damage had occurred in untreated plots, individual plants showing up to 11 larval mines per 6-leaved terminal.

Leaf damage due to *Austroascus viridigrisea* was evident soon after the crop appeared through the ground and increased in untreated plots until late in November. Colonies of *Macrosiphum gei* were present in early September, but disappeared later. Adults of *Epilachna 28-punctata* caused leaf damage in untreated plots by mid-October and had reinfested the DDT treated plots by harvest, but damage was of little consequence. Leaf defoliation had occurred on some plants in untreated plots by this time.

Though this soil type is prone to crack as it dries out, no noticeable cracks had occurred by early November. Slight cracking was noticeable when plots were harvested on December 12. The yield data from this trial are set out in Table 8, values being expressed as the mean for a 5-plant sample and the weights given in ounces.

Three DDT sprayings prevented larval infestation in the tops until early November and maintained a residual action sufficient to prevent serious reinfestation before harvesting. Though the DDT dust checked larval mining until early November, an appreciable larval population had developed in these plots by harvest. Larval activity was evident in untreated plots by early November (Fig. 3). Leaf mining increased rapidly later in the month and many plants had been largely defoliated when the plots were harvested. Differences between the number of mines counted per terminal for treatments at the final sampling on December 1 were significant at the 1% level.

Coupled with the effects of other pests in untreated plots, the leaf injury caused by *Gnorimoschema* reduced top growth considerably. This obvious effect was confirmed at harvest, when values for mean weight of tops produced showed increases of 27 and 19 per cent. for DDT spray and dust respectively. By protecting top growth, DDT, particularly in spray form, has greatly increased both number and weight of tubers produced. Spray and dust applications were equally effective in ensuring tuber formation, but the poorer residual action of the dust (Fig. 3), by allowing some top reinfestation while tubers were developing, resulted in a lower weight of tubers at harvest than was obtained in sprayed plots.

There is a suggestion (Table 8) that late hilling in particular has reduced top growth, but differences are not significant. It is to be expected that the lower leaves and prostrate stems would be covered by soil thrown up by implements, and this in itself would account for any reduction in top weight in late hilled plots. The cutting of surface roots may check top development also, but probably would be of lesser importance in the final results. Significant differences were obtained between the number of tubers produced in early hilled plots and those from plots receiving the other cultural treatments. These findings are also reflected in the weight of tubers produced, but differences are not significant.

Three applications of DDT spray, by preventing larval infestation in the tops, considerably reduced the likelihood of tuber infestation. In unhilled plots, only 3·3 per cent. of the tubers were infested, while hilling reduced this figure to less than 1 per cent. This benefit from spray application was reflected in the results for all three grades of tubers. DDT dust alone was of little benefit in preventing tuber infestation, as moths were able to reinfest plots before harvest.

Hilling alone reduced tuber infestation from 11·6 per cent. to less than 2 per cent. of the total tubers produced, with early and late hilling giving equal benefit in this respect. Such protection could not have been expected had harvesting been delayed.

Irrespective of treatment, the infestation recorded in first grade tubers was always lower than that for the other two grades.

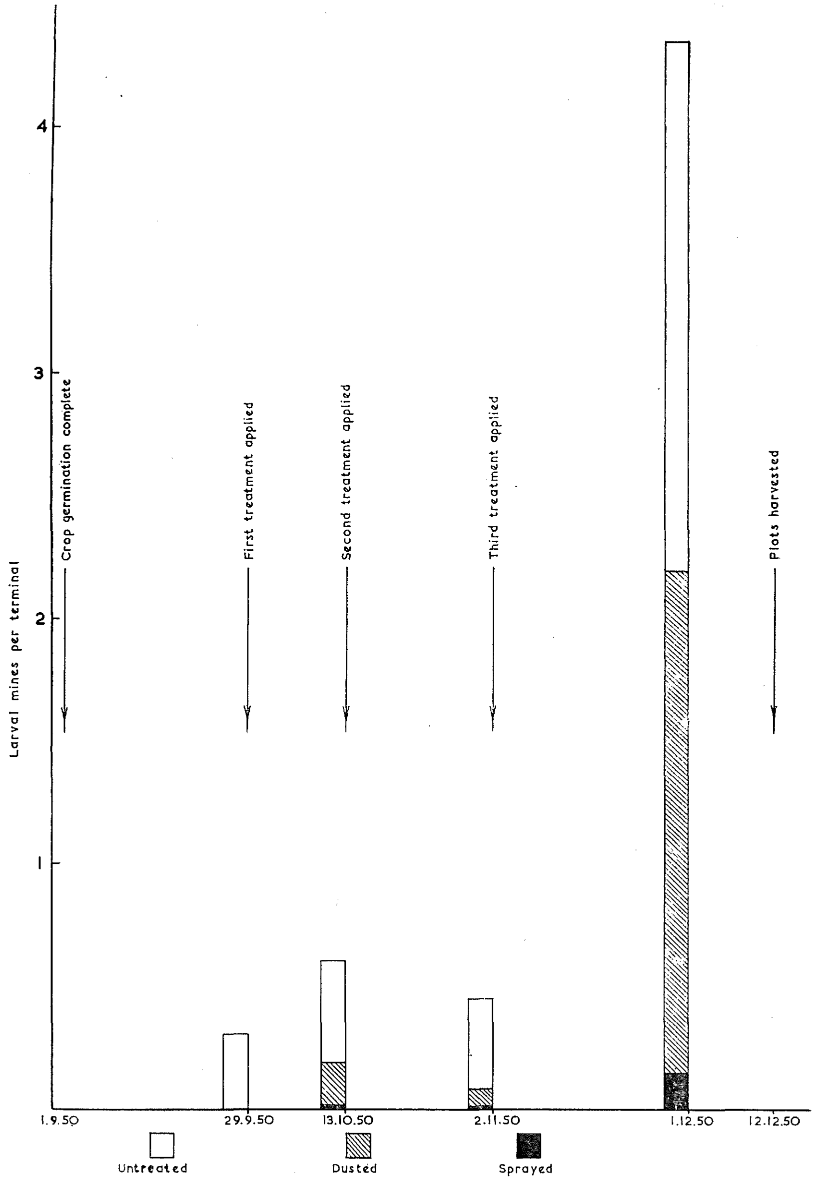

Fig. 3.

Diagram of Larval Mines per Terminal on Various Sampling Dates (Trial 2, 1950).

GENERAL DISCUSSION.

In the several experiments concluded, the value of both DDT and hilling in checking the ravages of *Gnorimoschema* was established repeatedly. Each was shown to fulfil a definite role in the control programme and the information obtained has suggested how each can best be applied in the field to benefit both *Gnorimoschema* control and general crop production.

The Role of DDT Applications.

Formulation of DDT Used.—At the concentration used, DDT spray was more effective than DDT dust in protecting the tops. Helson (1949) also came to this conclusion, though he found that dust applications were effective in late season crops, where populations waned as the season progressed.

Spray applications reduced moth populations rapidly and destroyed most larvae in their mines. Dusts were not as effective in these respects. Spraying was far superior in preventing larval mining in the tops in both 1950 trials, while reinfestation occurred much more rapidly in dusted plots once treatments were discontinued (Fig. 3). Variability in top damage between dusted plots suggested a less even cover of insecticide.

Figures for tuber infestation at harvest reflect the value of both methods of DDT application. In trial 2 of 1950, the infestation in dusted plots (15·1 per cent.) was significantly higher than in sprayed plots (3·3 per cent.). In fact, values for dusted plots were comparable with those for untreated plots, providing further evidence of the poor residual action of DDT dusts.

On a cost basis, spray is to be preferred to dust. Even if dusting was as effective as spraying, using 1 lb. active constituent per acre, the cost of dust would prove almost twice as much as that of spray.

Effect on Crop Development.—In the experiments reported, the weight of tops produced on sprayed plots was significantly greater than that on untreated plots. Greater differences occurred when early applications of DDT were necessary. Though the prevention of damage by *Gnorimoschema* larvae was largely responsible for these differences, the control of other potato pests by DDT would also contribute towards increased top development. The jassids *Austroasca viridigrisea, A. alfalfae* Evans and *Orosius* (*Thamnotettix*) *argentatus,* together with the potato aphis (*Macrosiphum gei*) were recorded from practically all experiments soon after germination and could be expected to influence the rate of early crop development, while the leaf eating ladybird (*Epilachna* 28-*punctata*), though rarely numerous before flowering, caused severe leaf damage in untreated plots before harvest.

Granovsky (1944) showed that DDT would prove effective against most insect pests of potatoes and these findings were borne out in these experiments. All the pests mentioned above were controlled following DDT applications and top growth could develop without check from insect attack.

Plots receiving adequate DDT spray applications made rapid and sustained growth and a comparison with untreated plants indicated that DDT treatment had stimulated plant development. Protection from the general insect population was reflected in the increase in both number and weight of tubers produced. Bald and Helson (1944) found that the yield of infected plants was approximately proportional to the amount of leaf area left undamaged by *Gnorimoschema* larvae. Hofmaster (1949) and Lloyd (1951) also suggested that control of *Gnorimoschema* in the tops should result in increased yields. Maximum increases in yield, apart from a greater percentage of sound tubers following pest control in the tops, can be expected to occur when the initial DDT application is made in the early stages of crop development.

Timing and Rate of Application.—Caldwell (1946) recommended that DDT treatment should commence with flowering, while Lloyd (1951) recommended application at the first sign of pest activity.

In the 1948 and 1950 experiments, DDT applied at the first indication of pest activity and followed by further applications as required was effective in preventing foliage injury for the greater period of crop growth, thus allowing maximum tuber development. Treatment applied late in the life of the crop may destroy populations before harvest but does not prevent foliage damage and its effect on yield. This was shown to be the case with the preharvest treatment in the 1948 experiment, and to a slight degree with the late treatment in trial 3 of the 1949 experiment.

Two applications of spray—the first when plants had only four to six leaves and the second 10 days later—were sufficient to control the pest during the 1948 experiment, the check to insect populations and associated stimulation of top growth being still evident at harvest. In the 1949 experiment, though 1 lb. of DDT per acre was applied at each application, the interval between applications was prolonged by rain to from four to six weeks and allowed *Gnorimoschema* to cause top damage in the interval between sprays and persist in sufficient numbers to damage tubers at harvest. For the 1950 experiments, three sprays with intervals of two to three weeks between applications gave excellent control in the tops and virtually prevented tuber infestation. It is possible that the third application was not necessary for additional top protection, though its benefit was reflected in the greater percentage of sound tubers harvested.

The results for the 1948 experiment were obtained when *Gnorimoschema* populations were high throughout the Lockyer Valley. Hofmaster (1949) found that two applications, 10 days apart, each applied at the rate of 1 lb. DDT per acre, were sufficient to control heavy infestations. Leaf mine counts in the 1950 experiment suggested that under the conditions of the experiment, DDT applied at the rate of 1 lb. per acre maintained its effectiveness for at least two weeks after application. Cannon (1948) argued that, at the same rate of application, the interval between treatments may extend up to three weeks.

Caldwell (1946) recommended three or four applications at fortnightly intervals, commencing with flowering. For effective top protection, earlier treatment is generally necessary and it seems that, if DDT is first applied when populations are low (preferably soon after crop germination), only two (or at the most, three) applications of DDT are necessary to cope with *Gnorimoschema* in seasons that favour its development. This schedule should be adopted as a routine measure, the application of the third treatment being dictated by the likelihood of further damage before harvest.

The Role of Hilling.

No detailed evaluation of hilling methods was undertaken. Lloyd (1943) investigated this point and found that it is necessary to ensure that the soil is well thrown up along the rows of plants so that all tubers are adequately covered with at least two inches of soil (Fig. 4). Though hilling is generally adopted by most potato growers in southern Queensland, the time of its application varies. Many growers hill their rows at or soon after flowering (Cartmill and Bechtel, 1951), though Lloyd (1946) recommended late hilling, up to 14 weeks after planting, when the tubers are commencing to swell and crack the ground.

Prevention of Tuber Infestation.—Hilling was shown to play an important part in protecting tubers from *Gnorimoschema* damage (Fig. 4). Langford (1933) was able to reduce tuber infestation from 18·27 per cent. to 5·5 per cent. by hilling alone, while Lloyd (1950) gave the figures 14·9 per cent. for unhilled and 4·2 per cent. for hilled plants. In trial 2 of 1950, tuber moth infestation was reduced

Fig. 4.
Potatoes Effectively Hilled Against Tuber Infestation by *Gnorimoschema operculella* (Zell.).

from 11·6 per cent. to 1·3 per cent. by late hilling, this difference being significant at the 1 per cent. level. Despite insecticidal applications, populations are not always entirely destroyed and some tuber infestation will occur in unhilled crops. Hilling, apart from controlling weed growth, seals cracks in the soil and, if properly applied, effectively checks *Gnorimoschema* damage until the crop can be harvested.

Hilling proves exceedingly beneficial if harvesting is unavoidably delayed. This effect was shown in trial 2 of the 1949 experiment, where a significantly lower infestation was still evident in late hilled plots despite major tuber moth activity over the experimental area following a delay of almost three weeks in harvesting. Hilling was responsible for even greater differences in tuber infestation in trial 3 of the same experiment, though only a slight delay in harvest had occurred.

Despite well formed hills, varieties such as Sarenac and Sebago that produce their crop on elongated stolons often have a percentage of their tubers either wholly exposed or only lightly covered with soil after the hills are formed. Hilling cannot be expected to eliminate tuber infestation entirely in these varieties, and appreciable damage may occur if harvesting is delayed.

Evidence was obtained (trial 2 of 1949 and trial 2 of 1950) that first grade tubers are less subject to infestation than tubers of smaller size. The majority of first grade tubers are formed early and thus are found deeper in the soil. Chats are formed later in the sequence of crop formation and lie close to the soil surface ; they are protected from *Gnorimoschema* damage only if a perfect hill is formed. First grade tubers provide the bulk of the total crop produced, and the benefit derived from hilling is further appreciated if other grades are left out of consideration.

Influence on Yield.—The results from these experiments suggest that a definite time interval between planting and hilling is desirable if the operation is not to interfere with yield. The early hilling treatment was applied soon after flowering, at a time when many tubers were being formed, while late hilling was designed to avoid this important period of crop formation. Often these treatments could not be applied at the intended time, due either to rain or to other unavoidable causes. A summary of the relevant data from the various experiments (Table 9) shows the relationship between time of hilling and tuber yield.

Disregarding varietal effects, hilling reduced yield when applied soon after flowering, or within 10 weeks of planting. Beyond this time interval, damage decreased until no depressing effect was apparent after an interval of 15 weeks. It would appear that early hilling, under certain circumstances, interferes with the formation of the tubers, but it is also likely to retard tuber development by temporarily checking plant growth.

Lloyd (1950) recorded a loss of up to 10 per cent. by weight due to hilling alone, and this finding was supported by these experiments (cf. trial 2 of 1949). The extent of the damage incurred depended not only on the age of the crop when hilling was carried out but also on the variety of potato being hilled. Hilling depressed the yield of Factor when applied up to 11 weeks after planting, but this

Table 9.

DATA SHOWING RELATIONSHIP BETWEEN TIME OF HILLING AND YIELD.

Variety.	Early Treatment.			Late Treatment.		
	Weeks after planting.	Percentage decrease in tuber yield.		Weeks after planting.	Percentage decrease in tuber yield.	
		Number.	Weight.		Number.	Weight.
			1949 Experiment.			
1. Sebago	..	..	..	15	..	..
2. Sarenac	8	13†	17*	11	24*	14†
3. Factor	8	..	11‡	11	..	9‡
			1950 Experiment.			
1. Sequoia	11	..	..	15	..	..
2. Sebago	10	21†	11‡	12	3†	7‡

* = sig. at 1 % level ; † = sig. at 5 % level ; ‡ = not significant.

decrease was not significant and was recorded for weight of tubers only. Sequoia showed no apparent reduction in yield when early and late hilling were applied 11 and 15 weeks respectively after planting. Considerable reduction in both number and weight of tubers was recorded for the variety Sarenac, though hilling times corresponded with those for Factor. Despite its application at greater time intervals after planting, hilling caused more damage to Sebago than to Factor.

Lloyd (1946) suggested that drying out of the soil following hilling was the main cause of yield reduction. This would not be an important consideration here, as all experiments were grown under irrigation and at no time during crop development was soil moisture inadequate. Hilling implements, by cutting feeding roots and mechanically damaging tops, could be expected to interfere with normal tuber development. Such damage would be reflected largely in a decreased weight of tubers at harvest.

Reduction in the number of tubers formed following hilling can be directly associated with the habits of the several varieties grown. Sequoia and Factor produced their tubers close to the base of plants. Both Sarenac and Sebago form their tubers on long stolons, and tubers were located in the soil up to 10 inches from the base of plants of the former variety. Hilling implements could be expected to destroy or damage many tubers of these two varieties.

Time of Application.—The spring potato crop in southern Queensland is usually ready for harvest in 16 to 17 weeks from the date of planting. From the evidence obtained (Table 9) it would seem that, to avoid undue crop damage, hilling should be carried out no earlier than 12 weeks from planting, though an extension of this time to 14 weeks, as recommended by Lloyd (1946), would obviate any possibility of damage to most varieties. If tubers are to be adequately protected from *Gnorimoschema* attack, hilling cannot be delayed later than 14 weeks from planting. The increased yield of sound tubers due to hilling alone will more than compensate for any depression in total yield that may occur when hilling is applied later than 12 weeks from planting.

CONCLUSIONS.

A schedule of DDT applications is essential for effective control of *Gnorimoschema* in the spring potato crops in southern Queensland. Two (or in extreme cases, three) applications of spray, each at the rate of 1 lb. DDT per acre, will prevent pest populations developing for the greater period of crop growth and so prevent any check to normal tuber formation and development. Applications should commence at the first sign of pest activity within the crop and be repeated at fortnightly intervals. If treatments are properly applied, their cost will be more than compensated by the extra yield of tubers obtained and the increased percentage of sound tubers at harvest.

The above schedule of DDT applications will not eliminate or prevent re-entry of *Gnorimoschema* populations late in the period of crop development. Hilling the plants between 12 and 14 weeks after planting will prevent effectively any likelihood of tuber infestation in the preharvest period. The hills should be constructed so that all tubers are well covered with soil and should be maintained against weathering during late rains or irrigation.

Hilling alone, without early DDT spraying, cannot be expected to protect tubers from *Gnorimoschema* damage, but can be regarded only as a supplementary measure for additional tuber protection and as a safeguard against crop reinfestation or delays in harvesting. Unlike DDT spraying, hilling does not ensure maximum yields.

Hilling does not entail any additional cost to the grower, as it is a normal and long established practice of potato culture in southern Queensland. However, every effort should be made to achieve correct timing.

As stated earlier, observation plots were established during the spring of 1951 to demonstrate the effectiveness of control measures recommended against *Gnorimoschema*. The recommendations followed were those published in an extension article (May, 1951) and based chiefly on work conducted during the previous three years and now reported in this paper. Extremely dry weather prevailed throughout spring and early summer and tuber moth was of more than usual importance in the area. Crops receiving inadequate DDT applications suffered heavily from tuber moth attack and poor yields of sound tubers were recorded. Where insecticidal treatment was applied early and continued in accordance with recommendations, tops developed normally. Late hilling adequately prevented damage prior to harvest, for less than 5 per cent. of harvested tubers were infested. These findings support the conclusions drawn from the trial data presented in this paper.

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