Mr. Peter Zuk of the Stored Product Insect Laboratory, Vancouver, identified the beetles as *Tribolium destructor* Utten. In our collections was one of two specimens I had taken in Vancouver in 1951 that were identified in 1954 by Dr. D. W. Boddy of Seattle as *Aphanotus brevicornis* Lec. A series sent to Mr. Gordon Stace-Smith was pronounced to be *A. brevicornis*. This is apparently a relatively rare beetle because Mr. Stace-Smith, Mr. H. B. Leech of the California Academy of Sciences and the Systematic Unit at Ottawa, were all glad to have a series. Mr. W. Brown of the Systematic Unit requested a living colony because the National Collection had no specimens of this species. After studying it, Mr. Brown reported that the insect is not *Aphanotus brevicornis* Lec., but is *Tribolium destructor* Utten. even as Mr. Zuk had identified it at first.

The original stock that the agent received and later gave me, probably developed in cereals, from which the larvae migrated to nearby tea leaves for pupation; they certainly do not feed on tea leaves.

—G. J. Spencer, University of British Columbia.

CHEMICAL CONTROL OF ROOT MAGGOTS IN EARLY CABBAGE[1]

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Eight large-scale experiments on chemical control of root maggots in early cabbage were conducted from the Victoria laboratory during the years 1947-1953 and 1955. The phase of the investigation relating to methods of evaluating damage and control has already been reported (King, Forbes, and Noble, in preparation).

Before 1920, controls recommended in North America were limited to cultural or mechanical methods (Goff, 1892; Slingerland, 1894; Schoene, 1916; Gibson and Treherne, 1916). Use of a tarred felt paper pad around the stem of each transplant, though effective, was very laborious and not commercially practical. Chemical control, in the usual sense, did not exist until Brittain (1920) published experimental evidence of the effectiveness and practical value of corrosive sublimate, previously reported (*e.g.*, Slingerland, 1894) to have been employed for many years by some commercial growers in Great Britain as a trade secret. Brittain's results were soon confirmed by other workers, and the effectiveness of calomel was demonstrated by Glasgow (1929) and others. Both of these chemicals were expensive and the labor cost was also high since repeated applications were necessary. Although these two chemicals continued for many years to be valuable standard remedies against root maggots, thorough re-investigation of the problem became imperative when, with the advent of the chlorinated hydrocarbons, there was promise of developing more economical controls (Carlson *et al.*, 1947). The materials first tried gave disappointing results (Dills *et al.*, 1944), but others later proved more effective (Eide & Stitt, 1950; Semenov 1950; and others). It was at the early stage of this development that the present study was begun.

The methods used to evaluate control measures have not always been discussed, especially in the earlier literature. Important exceptions include Brittain (1920), Wright (1953), and King *et al.* (in preparation). The latter concluded: (1) that yield on an area basis provides the best summation of the effects of attack and of chemical treatment, environmental factors being considered; (2) that yields from different experiments are best compared when each is expressed as a percentage of the yield of the highest-yielding treatment of its own

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experiment; and (3) that the number of plants ruined by maggots provides the best single measure of protection.

The cabbage maggot, *Hylemya brassicae* (Bouché), was the pest species involved in all the experiments. Infestation by first-generation larvae is the critical factor in the production of early cabbage in coastal British Columbia. Flies begin to emerge from overwintered puparia during the first long warm period in April or May and lay eggs about a week later (Table I).

TABLE I.—Seasonal data on egg-laying, transplanting, and harvesting for the experimental area, Victoria, B.C., 1947 - 1956.

Year	Beginning of egg-laying	Peak of 1st-generation eggs	Peak of 2nd-generation eggs	Trans-planting	Harvest
1947	April 23	—	—	April 11	June 17 - July 10
1948	April 26	—	—	April 16	July 20 - Aug. 3
1949	April 25	—	—	April 26	July 12 - Aug. 15
1950	May 8	—	—	May 25	Aug. 7 - Sept. 12
1951	May 3	—	—	June 5	Aug. 8 - Sept. 4
1952	April 24	May 26	July 7	April 17	July 21 - Aug. 13
1953	April 24	June 1	July 6	April 21	July 21 - Aug. 19
1954	—	May 31	July 9	—	—
1955	May 2	May 23	June 30	May 3	Aug. 2 - Aug. 12
1956	May 2	May 17	July 1	—	—

At Victoria early cabbages are transplanted to the field during April or May. Consequently the peak of spring egg-laying (Table I) occurs when the plants are still small and not fully established. They may also receive considerable numbers of second-generation eggs, but this infestation does not greatly affect production since the plants are then nearly mature.

Methods and Materials

All the experiments were conducted at Victoria, on a farm with clay-loam soil. A randomized block design was used each year except in 1950 and 1951, when a latin square design was used. There were four replications in 1947 and 1948, six in 1949 and 1955, seven in 1953, eight in 1952, and ten in 1950 and 1951. There were generally 40 to 60 plants per plot.

Plants were started in the greenhouse or in seed-beds protected from infestation. Transplanting dates are shown in Table I.

All plants were inspected frequently throughout the growing season to note dying plants and determine cause of death, and to record other pertinent data such as indications of phytotoxicity. Individual plant records were maintained. Harvest data were taken as groups of plants matured. Analysis of variance was used in evaluating the results.

Plants that died or failed to produce marketable heads from causes outside the scope of the experiment were not included in the final results. These included plants ruined by cultivation injury, flooding, wire stem, club root, muskrats, and cutworms. The number of plants involved was usually very small. The same procedure was followed in 1950, the one year when because of failure of protective measures in the seed-beds, some of the transplants were infested by root maggots when they were set out. As these plants succumbed much more quickly than those infested after transplanting, they were eliminated from consideration without affecting the appraisal of treatments.

TABLE II.—Percentages of early cabbage ruined and yields after various treatments against the cabbage maggot at Victoria, B.C., 1948-1955.

Treatment			Rate[1]	Number of Applications	Plants Ruined by Maggots, %						Yield[2]					
					1948	1949	1950	1952	1953	1955	1948	1949	1950	1952	1953	1955
Check			—	—	41	48	23	34	23	90	42	44	62	55	51	6
Corrosive sublimate		1:1600	3 oz./plant	3	9						66					
Calomel-talc	dust	4%	40 lb./acre	3	8						64					
	stem	50%	1 oz./250 plants	1	15						64					
Parathion	dust	2%	40 lb./acre	2	6						88					
Toxaphene	dust	10%	40 lb./acre	3	42						39					
DDT	dip	50%	0.5 oz.[1]	1			3	2					91	92		
	stem	50%	1 oz./250 plants	1	1	25	1				84	59	100			
	spray	50%	3 lb.	2		34						58				
BHC	dust	0.5%g	40 lb./acre	3	3	11	4				95	96	93			
				2		12	2					95	94			
				1		16	2	7				78	90	80		
	spray	50%	¼ lb.g	3	2		3				100		94			
				2		11						88				
				1		20						82				
Dieldrin	dust	1%	40 lb./acre	2			2						87			
				1			3						88			
	spray	emulsion[3]	1 lb.	1			2						95			
Chlordane	dust	5%	40 lb./acre	3	19						55					
		10%	40 lb./acre	2			8						86			
		10%	40 lb./acre	1			6						81			
		5%	40 lb./acre	1				12	4	46				73	71	44
	spray	emulsion[4]	2 lb.	2		10						100				
		emulsion[5]	2 lb.	1			1						93			
Aldrin	dust	1%	40 lb./acre	3			3						92			
				2			3						90			
				1			5						89			
		2.5%	40 lb./acre	1				1	3	7				78	100	100
	dip	emulsion[3]	0.2 oz.	1				1	0	0				83	89	90

	spray emulsion[4]	1 lb.	2			1						96			
			1			2						91			
	spray emulsion[3]	2.5 lb.	1				0	0					100	89	
Heptachlor	dust 10%	40 lb./acre	2			1						90			
			1			3						84			
	2.5%	40 lb./acre	1				1	1	9				94	91	87
	dip emulsion[3]	0.2 oz.	1					0	0					79	94
	spray emulsion[4]	1 lb.	1			2						93			
Difference necessary for significance:		at 5% level		15	11	1	9	6	16						
		at 1% level		20	14	2	12	8	23						

1 For dips: ounces of toxicant per gallon of dip. For sprays: pounds of toxicant per 100 gallons of spray, applied at 3 ounces per plant.
2 Percentage of yield for highest-yielding treatment of the year: 1948, 26.4 tons per acre; 1949, 13.6; 1950, 10.8; 1952, 10.9; 1953, 15.1; and 1955, 18.6.
3 Two pounds of toxicant per gallon.
4 Four pounds of toxicant per gallon.
5 Eight pounds of toxicant per gallon.

During the experiments, 10 insecticides were used in 41 treatments. The insecticides were: aldrin, BHC, calomel, chlordane, corrosive sublimate, DDT, dieldrin, heptachlor, parathion, and toxaphene. These were used in standard formulations of the period except as specifically noted.

Five methods of application were used: Dip and stem treatments were applied to the transplants just before they were replanted in the field. Drenches, dusts, and sprays were applied around the bases of the plants soon after they were set out, usually within two days.

In the dip treatments, the mixture was a wettable powder (DDT) or an emulsifiable concentrate (aldrin, heptachlor, chlordane) in water. The entire plant was immersed in the DDT mixture since this procedure protected the young plants from flea beetles. Only the roots and stems of the plants were dipped in the emulsions, however, because of the danger of phytotoxic effects from dipping the entire plant. No further treatment was given.

In the stem treatments, the transplants were moistened and the stems (not roots) dusted with approximately 1 ounce of dust per 250 plants. No further treatment was given.

The drench treatment was used only for applying corrosive sublimate solution, in 1947 and 1948. One-third to one-half of a cupful, approximately 3 ounces, of a 1:1600 solution was poured on the soil at the collar of each plant. There were three applications, at ten-day intervals, starting shortly after transplanting or at the beginning of egg-laying.

In the dust treatments, dust was applied with a puffer duster, one or two puffs on the soil around the collar of each plant, at approximately 40 pounds per acre. There were 1 to 3 applications, starting shortly after transplanting. Second and third applications were made at ten-day intervals.

In the spray treatments, a spray was applied to the soil around the collar of each plant with a bucket pump sprayer for a timed period, usually 5 seconds, predetermined to wet thoroughly the soil surrounding the plant. Approximately 3 ounces of spray were applied to each plant. There were 1 to 3 applications.

The treatments were evaluated on the basis of yields and plants ruined by maggots (King *et al.*, in preparation). The plants ruined comprised those killed by root maggot attack and those that because of root maggot attack failed to produce marketable heads weighing at least 12 ounces by the last harvest. For analysis, the number was expressed as a percentage. For determination of yields, marketable heads cut at each harvest from each plot were weighed, and the total weight and number of heads were recorded. The average weight per marketable head was calculated from these data. Yields per acre were calculated on the basis of 10,000 plants per acre and the percentage of plants ruined by maggot attack.

The varieties of cabbage used were: Green Acre, 1948 and 1949; Golden Acre, 1947 and 1950 - 1953; Cluseed, 1955. There was a single replicate of the variety Flowers of the Garden in the 1947 experiment.

Results and Discussion

Results of six years' experiments are given in Table II. In 1950, 1952, and 1953 the infestations were moderate, whereas in 1948 and 1949 they were heavy. The infestation in 1955, when 90 per cent of the untreated plants were killed by root maggots, was by far the heaviest encountered in the studies and provided a very severe test.

In the other two experiments, 1947 and 1951, root maggot infestations were too light to provide a critical test, less than 2 per cent of the untreated plants being killed in either case. In 1951 this was largely the result of late transplanting, so that the plants escaped first-generation infestation.

With stem brassicas, the critical period for damage by root maggots is the two or three weeks between transplanting and establishment (King *et al.*, in preparation). Infestation after the plants are established is less serious. To give satisfactory control, a treatment must provide almost complete protection at this time, but need not prevent all infestation later in the season. The critical period is long enough, however, to necessitate two or more applications of any treatments that have little residual effect.

The most effective and economical of all the materials were aldrin and heptachlor, as previously shown also for rutabagas (King & Forbes, 1954; King *et al.*, 1955; Forbes & King, 1956). One application of either aldrin or heptachlor dust gave almost complete control in every instance. These materials in spray form gave comparable results and also killed wireworms. Dip treatments gave the greatest reduction in maggot damage obtained, almost all the roots being free from feeding. However, they were sometimes phytotoxic. In the 1955 experiment each killed eight per cent of the plants, within two weeks after transplanting. A different commercial formulation applied at the same rate in 1955 by a co-operating grower showed no phytotoxicity to early cabbage, while providing almost complete control. Gould (1955) suggests several precautions that reduce or prevent phytotoxicity.

Dieldrin dust and spray were about equal to aldrin and heptachlor in effectiveness in the one year of trial.

In some of the early experiments, chlordane appeared to be rather promising. Fair control was obtained with a spray treatment in 1949 and 1950 and with a dust treatment in 1950. Later experiments, however, showed chlordane dust to be unreliable, particularly in heavy infestations.

Multiple applications of BHC dust or spray in the earlier experiments gave outstanding control. Single applications, tested in 1949 and 1950, gave somewhat poorer though still adequate commercial control.

The DDT stem treatment gave good control in 1948 and 1950. The DDT dip treatment used in 1950, 1951, and 1952, which was developed as a more rapid and convenient method of applying the DDT to the roots and stems, was also effective.

Two applications of parathion dust gave good control in 1948. Parathion was not tested further in view of the availability of other effective materials having much lower mammalian toxicity.

Corrosive sublimate drench and calomel-talc dust, each with three applications, were the standard treatments for maggot control in early cabbage in 1947. They were, therefore, included in the 1947 and 1948 experiments. The 1947 test was inadequate. In the 1948 experiment they gave reasonably good control but were surpassed by several other treatments, especially on the basis of yield and economy. For example, in 1948, yields with these treatments were only about two-thirds those with other treatments that afforded comparable reduction in maggot damage. The relatively low yields with these mercury compounds were probably attributable to their strongly phytotoxic properties. The calomel stem treatment showed a similarly reduced yield.

Toxaphene dust, chlordane dust, DDT spray, and calomel stem treatment were unsatisfactory as tested in these experiments.

Conclusions

To provide the best test of treatments against root maggots, stem brassicas should be exposed to the heaviest infestation possible. At Victoria this is usually achieved when the crop is transplanted to the field as early in the spring as growth conditions are suitable. The crop is then at the critical stage of growth, *i.e.*, between transplanting and establishment, when egg-laying by the adult of the cabbage maggot is at its peak. To achieve protection, it is essential to prevent attack for a least ten days after transplanting, and to minimize it for a further three or four weeks.

The eight years' field experiments demonstrated that corrosive sublimate drench and calomel-talc dust treatments, which were the standard treatments for maggot control on cabbage in Canada up to 1949, were inferior to treatments with the chlorinated hydrocarbons, especially on the bases of yield and cost. Aldrin and heptachlor were the most effective chemicals, a single application providing almost complete protection against very heavy infestations.

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DIPTERA TAKEN AT ROBSON, B.C.

H. R. FOXLEE

Robson, B.C.

Robson is in the southern part of the West Kootenay region of British Columbia, close to the northeastern corner of the State of Washington. The elevation is about 1410 feet.

The Diptera in this list were taken between 1939 and 1955.

ORTHORRHAPHA

NEMATOCERA

Anisopodidae

Anisopus alternatus Say.

Simuliidae

Prosimulium fulvum (Coq.)
Simulium arcticum Mall.
Simulium hunteri Mall.
Simulium tuberosum Lund.
Simulium vittatum Zett.

Fungivoridae (Mycetophilidae)

Ceroplatinae
Apemon negriventris Joh.
Ceroplatus terminalis Coq.

Sciophilinae
Dziedzickia fuscipennis (Coq.)
Monoclona elegantula Joh.

Fungivorinae
Rhymosia cristata (Staeg.)

Bibionidae

Bibio longipes Lw.
Bibio nervosus Lw.
Bibio slossonae Ckll.

BRACHYCERA

Stratiomyidae

Clitellariinae
Adoxomyia rustica (O.S.)

Stratiomyinae
Eulalia pubescens (Day)
Stratiomys barbata Lw.
Stratiomys maculosa Lw.

Geosarginae
Geosargus cuprarius (L.)
Geosargus decorus (Say)
Geosargus viridis (Say)
Microchrysa polita (L.)

Beridinae
Scoliopelta luteipes Will.

Rhagionidae

Rhagioninae
Rhagio concava Leon.

Chrysopilinae
Symphoromyia atripes Big.

Coenomyiidae

Arthroceras sp.
Xylophagus decorus Will.