Studies on the Seed-Corn Maggot. III.
On the Method of Control of the Seed-Corn Maggot. (I).

By

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Introduction.

Many experiments have been carried out, both in Japan and abroad, in order to find an effective method of control of the seed-corn maggot, *Hylemyia cilicrura* Rond. According to Hawley[1], Lintner suggested as early as 1882 the soaking of seed in gas tar to keep the maggot away. Headlee (1913) tried the application of sand, which was treated with carbolic acid, to the surface of the soil just after the beans were planted and a few more plants came up in the treated plots than in the checks. Later he found that a repellent effect on the maggots resulted from treating lima beans with coal-tar and dusting them with ashes, lime or tobacco dust. Hawley carried out, on a rather small scale, many experiments on the artificial method of control. A poisoned bait consisting of sodium arsenite, water and molasses was also tested for the adult insects of the seed-corn maggot. He came to the conclusion that neither the seed treatment nor the other artificial control measures gave promise of success.

In Japan, also various substances such as dry sand, mixture of pyrethrum powder and wood-ash, saw dust treated with coal-tar, cresin, naphthalene, sulfur, tobacco dust etc. were tried either for treating the seed or for applying on the soil as a method of prevention. Besides, it has often been recommended that the use of human manure or of fish manure as a fertilizer should be avoided as far as possible.[2), 3), 4), 5)]

While some of these substances which had been tested thus far in Japan as well as in foreign countries were of some value, some of them at the same time were fairly injurious to sprouting seeds. The effect of other substances on the seed-corn maggot have not yet been definitely determined.

As is well known, the seed-corn maggot is remarkably polyphagous in its food habit and grows well by feeding on fish manure, cotton seed meal and other decaying vegetable and animal matter. Thus, sprouting seeds are not necessary

for its growth.[1),6),7)] According to the observations of the writers, cotton seed meal strongly attracts the adult insect of the seed-corn maggot and the seed-corn maggot feeds on it and grows well. Moist soil of a newly plowed field attracts many flies even when neither human manure nor fish manure are used. Avoiding the use of such manures as human excreta or fish manure diminishes the injury caused by the seed-corn maggot, but this method of manuring alone is not sufficient to prevent the attack by this insect.

KÄSTNER tried poisoned baits to kill the adult insect of the onion maggot and obtained a fairly good result.[8)] PETERSON reported the result of experiments in which he captured the flies of the onion maggot and the seed-corn maggot by using a fly trap.[9)]

As has been mentioned above, many experiments were carried out to prevent the attack of the seed-corn maggot, but the results which had been obtained can not be looked upon as conclusive. As regards the method of killing either the adult insect or the maggot, experiments seem to be rather scarce.

In consideration of these circumstances, the writers conducted some experiments in the hope of finding some means of killing the seed-corn maggot as well as those of preventing the attack by this insect. The results thus far obtained are reported in the present paper.

I. Method of Killing the Seed-Corn Maggot.

HEADLEE tried solutions of corrosive sublimate, sulfocide and potassium cyanide in an effort to kill the maggot, but the results were unsatisfactory. HAWLEY tested many substances; some of them were used apparently for killing the egg and maggot and the others for preventing oviposition of the adult insect. According to his experiments, some of the materials tested, for example, kerosene, tarred sand (these two were applied on the soil), Bordeaux paste (applied on seeds), calcium cyanamid (placed in the row with the planted seeds), etc. gave a fairly good control, but most of them, excepting Bordeaux paste, either severely injured the germination of the seeds or retarded the growth of the seedlings. HAWLEY concluded that it seemed to be unwise to rely on control measures of this type in New York.

In order to know if there is any method of killing the seed-corn maggot, the writers carried out a series of laboratory experiments before undertaking the field experiment. The results of these experiments will be briefly described below.

1.) *Submergence.*

Certain insects which live in soil are said to be successfully controlled by flooding the field with water. Thus, this method is sometimes recommended in Europe for the control of the Phylloxera of grape vine. In Japan, the same

method is sometimes used for the larvae of a certain injurious may-beetle. In order to learn whether this method can be applied successfully for the control of the seed-corn maggot, the following experiments were conducted.

Immersion of the egg. The eggs of the seed-corn maggot survived immersion for 5 days at room temperature in April and May. No eggs were killed by immersion for 3 days when the temperature of the water was 15°C. When eggs were immersed for 3 days in water of a constant temperature of 30°C., only 50 per cent were killed.

Immersion of the larva. Under room temperature, in April and May, the majority of larvae survived immersion for 2 days. When the duration of immersion was 4 days, the majority died. Immersion for 4 days at a constant temperature of 20°C. killed almost all the larvae. Immersion for 2 days at a constant temperature of 30°C. killed most of the larvae. When the temperature of the water was 12°C., immersion for 6 days killed only a few larvae.

Immersion of pupae. No pupae were killed by immersion for 4 days under room temperature in June. Many pupae survived immersion for 2 days when the temperature of the water was 30°C. When the duration of immersion was increased to 4 days, nearly all were killed.

These results show that the effect of immersion differs greatly according to the temperature of the water in which the seed-corn maggot is immersed. If the temperature of the water is below 15°C., it is difficult to kill a considerable percentage of any of the three stages, the egg, the larva or the pupa, unless the duration of immersion is fairly long. When the temperature of the water is 30°C., immersion for 4 days kills nearly all of the larvae and pupae, but approximately 50 per cent of the eggs may survive even this immersion. Under field conditions it would be difficult to keep the water submerging the field at a constant temperature of 30°C. for 24 hours even in summer. As the writers have shown, the seasons in which the seed-corn maggot occurs abundantly are from March to June and from the later part of September to November. In these seasons it would be impossible to keep the water in the field at such a high temperature as 30°C. Therefore, it may be concluded that submergence of the field is not effective as a method of control of the seed-corn maggot.

2.) *Effect of various insecticides on the egg, the larva and the pupa.*

The object of this experiment was to determine whether it is possible to kill the egg, larva or pupa in the soil by applying a contact insecticide on the soil.

A. Experiments on the egg.

Preliminary experiments were carried out using pyrethrum, tobacco, nicotine sulphate, neoton, cresol soap, Goto's desin, Derris soap and lime-sulfur. Eggs were plunged into these insecticides, which were prepared in liquid form, and kept in them until living eggs hatched. It was found that desin was the most

toxic to the egg of the seed-corn maggot. Accordingly, experiments were then conducted with this substance under conditions which were more nearly similar to those in the field than in the preliminary experiments. The method of experimentation was as follows: The soil which was to be used for the experiment was first sprayed with the solution of the insecticide to be tested. Eggs were placed on the soil and covered with a thin layer of moist soil. The number of eggs that subsequently hatched were counted. The results of experiments are shown in Table I.

Table I.

Effect of Desin on the Egg in the Soil.

Dilution (Times the Original Volume)	Number of Eggs used	Number of Eggs killed	Remarks
50	15	15	June, 1931. Dry soil.
100	„	„	„ „
„	„	10	„ „
200	„	11	„ „
500	„	0	„ „
1000	„	0	„ „
2000	„	0	„ „
100	„	8	June, 1931. Wet soil.
500	„	0	„ „
1000	„	0	„ „
2000	„	0	„ „

According to the results shown in Table I, some of the eggs remained alive when desin was used at a concentration of 1 part (in volume) to 99 parts of water. When it was used at a dilution of 500 times its original volume, no eggs were killed. Thus, it is evident that even desin, the most toxic of the substances used by the writers for the egg, had a rather weak toxicity towards the egg of the seed-corn maggot when it was tested under approximately natural conditions. It must be remembered that nearly 50 per cent of soy-beans failed to germinate when they were planted in soil sprayed with a large quantity of desin which was diluted to 100 times the volume of the original liquid.

B. Experiments with the larva.

i.) Toxic action of various insecticides in liquid form. Larvae were first immersed in a solution of insecticide for a short time. Then, they were placed on the soil in a breeding cage, and observed to determine whether they could continue to develop or not. Larvae which revived later went into the soil and emerged as adult insects. The results of experiments are shown in Table II.

Table II.

Effect of various Contact Insecticides on the Seed-Corn Maggot. (i.)

Kind of Substance	Dilution (Times the Original Volume)	Number of Maggots used	Number of Maggots died	Remarks
Desin	Original Fluid	20	20	April, 1931.
„	10	10	1	November, 1930.
„	20	20	4	April, 1931.
„	20	10	1	December, 1930.
„	50	„	3	November, „
„	„	„	„	„ „
„	100	„	0	„ „
Cresol Soap Solution	20	20	11	April, 1931.
„	50	10	5	November, 1930.
„	„	20	7	April, 1931.
Nicotine Sulphate	100	10	1	December, 1930.
„	300	„	2	„ „
„	500	„	0	November, 1930.
Emulsion of Kerosene Extract of Pyrethrum	Original Fluid	20	0	April, 1931.
„	5	„	5	„ „
„	10	„	1	„ „

Remark: The cresol soap used by the writers was that of the Japanese pharmacopoeia.

ii.) Toxic action of various insecticides in powder form. Larvae were first moistened by dipping them in water for a while and then they were immediately rolled over the insecticide to be tested. When a considerable amount of the insecticide adhered to the body, they were placed in a glass vessel with a small quantity of soil at the bottom and their subsequent behavior was observed. The results obtained are shown in Table III.

Table III.

Effect of various Contact Insecticides on the Seed-Corn Maggot, (ii.)

Kind of Insecticide	Ratio of Ingredients which were mixed	Number of Maggots used	Number of Maggots died in Larval State
Pyrethrum Powder	pure	20	1
Pyrethrum and Wood-ash	1:4	„	1
„	1:9	„	2
Tobacco Powder	pure	„	2
Tobacco and Wood-ash	1:4	„	6
„	1:9	„	6
Leucothoe Powder	pure	„	0
Leucothoe and Wood-ash	1:4	„	3
„	1:9	„	1

Remarks: The ratio of ingredients which were used in making a mixture is shown in weight.
The tobacco powder which was used by the writers was the one prepared by the Imperial Monopoly Bureau of Tobacco from the waste product of tobacco and it contained certain amounts of quicklime and sulfur.

As it is evident from the data in Table II and III, the larvae of the seed-corn maggot were fairly resistant to each of the insecticides used for these experiments and these do not seem promising for application against the maggots which are found in the soil.

C. Experiments with the pupa.

Series (i.) The method of experiment was similar to that used in the experiments with the egg and the larva. The results of experiments are shown in Table IV.

Table IV.

Effect of various Insecticides on the Pupa. (i.)

Kind of Insecticide	Dilution or Ratio of Ingredients which were mixed	Number of Pupae used	Number of Pupae died
Emulsion of Kerosene Extract of Pyrethrum	Original Fluid	20	9
„	5	„	6
„	10	„	10
„	30	„	6
„	50	„	7
Desin	20	„	2
„	50	„	0
Nicotine Sulphate	100	„	0
„	200	„	0
Pyrethrum Powder	pure	15	8
Pyrethrum and Wood-ash	1:4	„	9
Tobacco Powder	pure	„	13
Tobacco and Wood-ash	1:4	„	6
Leucothoe Powder	pure	„	10
Leucothoe and Wood-ash	1:4	„	5

Remarks: Dilution and ratio of ingredients are expressed in the same manner as in Table II and Table III.

Series (ii.) The procedure was modified slightly. Approximately 200 grams of soil was placed in a glass pot and pupae were buried in the soil at a depth of about 1 centimeter. A sufficient amount of the solution of insecticide to be tested was poured upon the soil so that the pupae in the soil were moistened with the solution. Several days later, the number of adults that emerged were counted. The results of these experiments are shown in Table V.

Table V.

Effect of various Insecticides on the Pupa. (ii.)

Kind of Insecticide	Dilution	Number of Pupae used	Number of Pupae died
Emulsion of Kerosene Extract of Pyrethrum	20	20	0
"	50	"	"
Desin	20	"	17
"	50	"	5
Nicotine Sulphate	100	"	0
"	200	"	0

According to the results of the two series of experiments described above, the percentage of pupae killed by these treatments was rather low. Especially poor results were obtained in the second series of experiments. In the first series of experiments, a fairly good kill was obtained with tobacco powder, but whether or not as great a percentage can also be killed when it is used in field experiments is rather doubtful.

All experiments which have been described above were carried out in the laboratory on a small scale. Therefore, we may not be justified in drawing a conclusion from the results of these experiments. On the whole, however, these methods of combatting the seed-corn maggot do not seem promising as a practical method of control.

3) *Bait trap for the adult insect.*

SANDERS stated that the damage by the onion maggot could be greatly reduced by spraying the onion field with a poisoned bait which killed gravid females before they deposited their eggs.[10] Similar results were also obtained for the same insect by KÄSTNER, as has already been mentioned. The preoviposition period of the seed-corn maggot is roughly from one to two weeks in the seasons when these flies are abundant. May it, then, not be possible to kill the adult insect during the preoviposition period and to reduce the damage by this insect? First of all, it is desirable to know what substances are suitable as the attrahent for the adult of the seed-corn maggot. In his bait trap experiments on the onion maggot and the seed-corn maggot, PETERSON tested many substances and found that the following ones had a fairly strong degree of attractiveness when a small quantity of molasses was added: Ethyl alcohol, butyl alcohol, allyl alcohol and isopropyl alcohol. Two species were concerned with in his experi-

ments and it is not possible for the present writers to know from his report what substances were attractive to the adult of the seed-corn maggot.

Considering these experiments as well as the writers' observations on the habits of the seed-corn maggot, the following substances were tested in the experiments described below: Methyl acetate, methyl butyrate, ethyl butyrate, methyl formate, ethyl alcohol, honey, molasses, human excreta, ammonia, cotton seed meal and dried pupae of the silkworm.

The trap used for the experiment was a fly-trap made of glass. A small quantity of the material to be tested was placed in a shallow glass dish and this was covered with the fly-trap which contained a small quantity of soap solution. The flies which entered the trap fell into the soap solution and died.

Esters were insoluble in water. They were first diluted with an equal volume of alcohol. The resulting solution was termed the *stock solution* and diluted with water to a desired strength for use in experiments. The alcohol used was ethyl alcohol which contained alcohol at a rate of approximately 94 per cent. The original fluid of ammonia was a 30 per cent solution. For some experiments these substances were used alone, i. e., without mixing any other substance with them, while for other experiments a mixture of 2 different substances was used.

In some cases where the number of flies captured was rather small, due to the fact that active flies were not very abundant in the field, 2 experiments in which the substances used were essentially the same did not always show a consistent result for some unknown cause. The results of such experiments were considered as unreliable. To increase the reliability of experiments as well as to facilitate the comparison of results, two or more experiments in which the same substances were tested were taken together in tabulating results of experiments. The results obtained are shown in the following tables (Tables VI to XVIII):

Table VI.

Results of Bait Trap Experiments. (i.)

	Water Solution of Ammonia		Mixture of Methyl Acetate and Alcohol		Mixture of Methyl Butyrate and Alcohol		Alcohol	
Sex of Flies captured	♀	♂	♀	♂	♀	♂	♀	♂
Number of Flies captured	29	4	45	8	34	5	23	4
Total captured	33		53		39		29	

Remarks: Experiments Nos. 1—4 in the spring of 1930.
Ammonia was diluted to 20—50 times the volume of the stock solution.
Esters were used at a dilution of 30 times the volume of the stock solution.
Alcohol was used after diluting with water to 40—60 times the volume of the original solution.

Table VII.

Results of Bait Trap Experiments. (ii.)

	Mixture of Methyl Butyrate and Alcohol		Honey Solution		Cotton Seed Meal		Human Excreta	
Sex of Flies captured	♀	♂	♀	♂	♀	♂	♀	♂
Number of Flies captured	72	8	64	16	179	45	52	10
Total captured	80		80		224		62	

Remarks: Experiments Nos. 5 and 6 in the spring of 1930.
Methyl butyrate.....at a dilution of 30 times the stock solution.
Honey solution ..... 20% in weight.

Table VIII.

Results of Bait Trap Experiments. (iii.)

	Alcohol		Mixture of Methyl Butyrate and Alcohol		Mixture of Methyl Acetate and Alcohol		Cotton Seed Meal	
Sex of Flies captured	♀	♂	♀	♂	♀	♂	♀	♂
Number of Flies captured	82	32	14	6	47	14	270	54
Total captured	114		20		61		324	

Remarks: Experiments Nos. 7 and 8 in the spring of 1930.
Esters .....at a dilution of 20 times the stock solution.
Alcohol.....at a dilution of 20 times the original fluid.

Table IX.

Results of Bait Trap Experiments. (iv.)

	Mixture of Methyl Butyrate and Alcohol		Cotton Seed Meal		Human Excreta	
Sex of Flies captured	♀	♂	♀	♂	♀	♂
Number of Flies captured	86	14	439	99	98	28
Total captured	100		538		126	

Remarks: Experiments Nos. 5—8 in the spring of 1930.
Ester.....diluted to 30 times in Experiments Nos. 5 and 6, and to 20 times in Experiments Nos. 7 and 8.

Table X.

Results of Bait Trap Experiments. (v.)

	Alcohol Solution		Human Excreta		Solution of Ammonia		Cotton Seed Meal		Dried Pupae of Silkworm	
Sex of Flies captured	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂
Number of Flies captured	29	17	27	7	31	17	172	56	314	103
Total captured	46		34		48		228		417	

Remarks: Experiments Nos. 9 and 10 in the spring of 1930.
Alcohol.....diluted to 20 times the original liquid.
Ammonia.....diluted to 20 times the original solution.

Table XI.

Results of Bait Trap Experiments. (vi.)

	Mixture of Methyl Butyrate and Alcohol		Mixture of Methyl Acetate and Alcohol	
Sex of Flies captured	♀	♂	♀	♂
Number of Flies captured	48	11	63	19
Total captured	59		82	

Remarks: Experiments Nos. 1, 2, 7 and 8 in the spring of 1930.

Table XII.

Results of Bait Trap Experiments. (vii.)

	Mixture of Methyl Butyrate and Alcohol		Water Solution of Honey	
Sex of Flies captured	♀	♂	♀	♂
Number of Flies captured	106	13	86	18
Total captured	119		104	

Remarks: Experiments Nos. 1, 2, 5 and 6 in the spring of 1930.
Ester .....30 times the stock solution.
Honey.....20% solution.

Table XIII.

Results of Bait Trap Experiments. (viii.)

	Alcohol		Human Excreta	
Sex of Flies captured	♀	♂	♀	♂
Number of Flies captured	111	47	66	25
Total captured	158		91	

Remarks: Experiments Nos. 7—10 in the spring of 1930.
Alcohol.....20 times the original solution.

Table XIV.

Results of Bait Trap Experiments. (ix.)

	Human Excreta		Cotton Seed Meal		Dried Pupae of Silkworm	
Sex of Flies captured	♀	♂	♀	♂	♀	♂
Number of Flies captured	66	13	257	94	438	162
Total captured	79		351		600	

Remarks: Experiments Nos. 9—12 in the spring of 1930.

Table XV.

Results of Bait Trap Experiments. (x.)

	Methyl Butyrate and Alcohol		Ethyl Butyrate and Alcohol		Methyl Acetate and Alcohol		Molasses Solution		Ammonia Solution		Dried Pupae of Silkworm	
Sex of Flies captured	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂
Number of Flies captured	6	0	2	5	2	0	11	1	9	0	61	7
Total captured	6		7		2		12		9		68	

Remarks: Experiments Nos. 1—4 in the autumn of 1930.
Esters .....at a dilution of 70 times the stock solution.
Molasses .....50% water solution.
Ammonia.....70 times the original liquid.

Table XVI.

Results of Bait Trap Experiments. (xi.)

	Methyl Butyrate and Alcohol		Ethyl Butyrate and Alcohol		Mixture of Molasses and Ammonia		Dried Pupae of Silkworm	
Sex of Flies captured	♀	♂	♀	♂	♀	♂	♀	♂
Number of Flies captured	38	2	67	2	63	5	692	91
Total captured	40		69		68		783	

Remarks: Experiments Nos. 24—27 in the spring of 1931.
Esters.....70 times the stock solution.
Ammonia was dissolved at the rate of one part in 69 parts of 50% solution of molasses.

Table XVII.

Results of Bait Trap Experiments. (xii.)

	Methyl Butyrate and Alcohol		Ethyl Butyrate and Alcohol		Methyl Acetate and Alcohol		Ammonia Solution		Dried Pupae of Silkworm	
Sex of Flies captured	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂
Number of Flies captured	8	0	22	2	18	0	16	2	554	29
Total captured	8		24		18		18		583	

Remarks: Experiments Nos. 28 and 29 in the spring of 1931.
Esters .....35 times the stock solution.
Ammonia.....35 times the original solution.

Table XVIII.

Results of Bait Trap Experiments. (xiii.)

	Ethyl Butyrate and Alcohol		Methyl Acetate and Alcohol		Ammonia Solution		Cotton Seed Meal		Dried Pupae of Silkworm	
Sex of Flies captured	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂
Number of Flies captured	74	9	103	30	172	62	400	92	761	202
Total captured	83		133		238		492		963	

Remarks: Experiments Nos. 30—35 in the spring of 1931.
Esters .....70 times the stock solution.
Ammonia.....70 times the original solution.

Discussion of the results of the bait trap experiments.

As has been already stated, the results of experiments conducted with the same substances were not always consistent when active flies were scarce. In other words, the number of flies captured was not always proportional to the attractiveness of the substance which was used for an experiment carried out under such conditions. However, such inconsistent results appeared only in those experiments in which substances of weak attractiveness were used or in cases where there was no marked difference in attractiveness between the substances used. Therefore, the number of flies captured by a substance may be looked upon as representing the attractiveness of that substance to the fly, if precautions are taken in examining the results of experiments to guard against a mistaken interpretation which may be made in such exceptional cases as have been mentioned above.

Esters and alcohol. The esters which were used by the writers were such substances as are considered to be constituents of the ordour of a flower or of a ripe fruit. According to Tables VI and VIII, addition of esters to alcohol does not seem to increase the attractiveness of alcohol to the adult of the seed-corn maggot. The results in Table VIII might seem to indicate that alcohol alone had a stronger attractiveness than the mixture of ester and alcohol, but this apparently contradictory result seems to have been due to the fact that in *Experiments Nos. 7 and 8* alcohol of a stronger concentration was used than in *Experiments Nos. 1 to 4*. These results seem to show that the adult of the seed-corn maggot differs in its response to odorous substances from the adult of Drosophila which is strongly attracted by the odour of ripe fruits.

Comparison of attractiveness of esters. Esters which were used for the experiments were methyl butyrate, ethyl butyrate, methyl acetate and methyl formate. Of these 4 kinds, methyl formate was the least attractive to the adult of the seed-corn maggot. Methyl ester of acetic acid and that of butyric acid did not differ much in their attractiveness. However, the results of experiments seemed to indicate that methyl acetate was slightly more attractive than methyl butyrate (Tables VI, VIII, XI and XVIII). When esters of butyric acid were compared, it was found that ethyl butyrate was slightly more attractive than methyl butyrate (Tables XVI and XVII).

Esters and honey. Mixture of ester and alcohol had almost the same attractiveness to the adult of the seed-corn maggot as the water solution of honey (Tables VII and XII).

Alcohol, mixture of ester and alcohol, ammonia and human excreta. According to Tables VI, VII, IX, X, XIII and XVIII, the results of all experiments did not agree accurately, but it seems possible to conclude that these substances were nearly equally attractive to the adult of the seed-corn maggot. It is interesting to note that ammonia had a fairly strong degree of attractiveness and also that human manure did not possess a stronger power of attractiveness than the other substances.

Silkworm pupae and cotton seed meal. These two substances were used in the

dry state, i. e., they were not mixed either with water or any other liquid substances. Dried pupae of the silkworm had a peculiar smell which is common to decaying animal matter. No doubt the smell of the pupae of the silkworm contained the smell of ammonia gas. Cotton seed meal had also a peculiar smell which, however, was different from that of the silkworm pupae. It did not smell like ammonia. In spite of such a difference between these two substances, both of them were strongly attractive to the adult of the seed-corn maggot. Indeed, they were markedly more attractive than any other substances which were used in the present experiments. Dried silkworm pupae, in particular, were conspicuously attractive and attracted markedly more flies than cotton seed meal, as is evident from Tables X, XIV and XVIII. It is worthy of note that these two substances continued to be attractive for a fairly long period, while the other substances lost their attractiveness in a few days. Human manure has been considered in Japan as a markedly attractive substance to the adult of the seed-corn maggot, but it was surprising to find that cotton seed meal was conspicuously more attractive than human excreta. This suggests that the application of cotton seed meal as a fertilizer should be avoided as far as possible in order to prevent damage by the seed-corn maggot.

Value of the bait trap method as a practical means of control.

From the results of experiments described in the previous paragraph, it is evident that it is possible to capture the adult flies of the seed-corn maggot by using silkworm pupae or cotton seed meal as bait. The writers have not yet tried this method as a practical means of control. However, it seems to be possible to kill a considerable number of the adult flies before they begin to oviposit by using poisoned silkworm pupae or cotton seed meal as SANDERS or KÄSTNER did by using certain substances. Thus, the bait trap method may prove to be a practical method of control of the seed-corn maggot. The writers wish to carry out some experiments in connection with this problem.

II. Method of Preventing Damage by the Seed-Corn Maggot.

The preventive measures which have been recommended thus far in Japan may be classified into the following four groups: (1) To avoid the application of such manures and fertilizers as human excreta or fish-manure so far as it is practicable to do so; (2) to mix with manures such substances as will repel the adult flies when the use of human manure or fish manure is unavoidable; (3) to spray or sprinkle on the surface of the field substances which have repellent action to the adult of the seed-corn maggot or which mechanically prevent oviposition by the adult insect and (4) to treat the seed with such chemicals as protect the seed from the attack of the seed-corn maggot.

Of these four kinds of preventive measures, the first is a fairly effective method judging from the results of experiments conducted at several prefectural experiment stations in Japan. When the use of human excreta as a manure is desirable, other methods of prevention must be adopted.

As regards the second method of prevention, experiments were carried out at the Miyazaki Agricultural Experiment Station. According to the results obtained there, naphthalene, cresin, *arbos*, and petroleum seemed to have a repellent action to the seed-corn maggot, but they were found to be injurious to the germination of seeds. Dry fine sand also seemed to have a repellent action when it was strewn over the field in a thick layer, but it affected the growth of seedlings considerably.

Pyrethrum and tobacco were tested at the Kagoshima Agricultural Experiment Station. These substances were strewn over the surface of the soil, but their effectiveness as a preventive measure was not apparent from the results obtained there. As a seed treatment, coal-tar was tested by coating seeds with a thin layer of it. This was found to injure the germination of seeds as well as to affect the growth of young seedlings.

This short note on the results already obtained by investigators in Japan seems to indicate that further studies are needed in regard to the effectiveness of various preventive measures and also with regard to their effect on seeds and seedlings. Therefore, the writers undertook some experiments regarding the third and the fourth groups of preventive measures mentioned at the beginning of this paragraph, namely, the method of repelling the adult insect and that of the treatment of seeds.

1.) *Method of repelling the adult insect.*

Various substances which seemed to prevent the adult insect from depositing eggs were tested. Substances which were in liquid state were sprayed on the soil while those in powder form were strewn over the soil of the field after seeds were planted. Since the seed-corn maggot was usually not abundant in the experimental field around the institute, all the experimental plots were first sprinkled with diluted human manure to attract the flies of the seed-corn maggot. The manure was covered with a thin layer of soil and seeds were then planted. On one of the plots no repellent substance was used and this served as the check plot. Soy-bean seeds were used by the writers as the material for experiments.

The results of experiments are briefly described below.

Experiment 1. This was carried out in the spring of 1930. The size of a plot was one *tsubo*. Liquid substances were used at the rate of 1 litre per *tsubo*. The results of the experiment are shown in Table XIX.

Experiment 2. Carried out in the spring of 1931; size of one plot...1/3 *tsubo*; quantity of liquid substance...500 cc. per plot; quantity of material in powder form...300 grams.

The results of the experiment are shown in Table XX.

Table XIX.

Experiments with Repellents. (i.)

Plots	Total Number of Beans examined	Number of Beans injured	Per cent of Beans injured	Number of Maggots in wormy Beans
No Manure, No Repellent	475	23	4.8	13
Check	450	56	12.4	75
Cresol Soap	437	76	15.1	183
Tobacco and Wood-ash	424	58	13.7	86
Lime-sulphur	454	67	14.7	96
Lubricating Oil Emulsion	387	61	15.7	104
Pyrethrum and Wood-ash	428	75	17.5	59
Coal-tar Emulsion	441	49	11.1	66

Remarks: Cresol soap was used at a dilution of 50 times the volume of the original fluid.

Mixture of tobacco powder and wood-ash.....one part in weight of tobacco and 4 parts of wood-ash.

Lime-sulphur.....at a concentration of 3° Baumé.

Lubricating oil emulsion was used after diluting to 50 times the volume of the stock solution. The formula for the stock solution was as follows: Lubricating oil 1.8 litres, soap 56.3 grams, water 0.9 litre.

Mixture of pyrethrum and wood-ash.....one part of pyrethrum and 4 parts of wood-ash.

Coal-tar emulsion was prepared according to the following formula: Coal-tar 100 cc., fish-oil soap 6 grams, potassium hydroxide 2 grams and water 100 cc. The emulsion was used at a dilution of 10 times the stock solution.

Table XX.

Experiments with Repellents. (ii.)

Plots	Total Number of Beans examined	Number of Beans germinated	Number of Beans injured	Per cent of Beans injured	Number of Maggots in wormy Beans
No Manure, No Repellent	544	221	16	2.9	10
Check	605	75	93	15.3	49
Cyanogas A	709	197	85	11.9	37
Desin	452	94	42	9.2	21
Nicotine Sulphate	498	77	88	17.7	56

Table XX continued.

Plots	Total Number of Beans examined	Number of Beans germinated	Number of Beans injured	Per cent of Beans injured	Number of Maggots in wormy Beans
Naphthalene and Wood-ash	550	59	26	4.7	17
Cresol Soap	514	58	143	27.8	195
Pyrethrum and Wood-ash	555	68	48	8.6	44
Tobacco and Wood-ash	666	84	42	6.3	13
Covered with Newspaper	614	381	13	0.2	9

Remarks: "Number of beans germinated" is used to denote the number of seedlings which appeared above the surface of the soil.

Desin.....50 times the original fluid; nicotine sulphate.....250 times the original fluid; cresol soap.....50 times the original fluid; naphthalene and wood-ash.....one part of naphthalene to 2 parts of wood-ash; pyrethrum and wood-ash.....one part of pyrethrum to 2 parts of wood-ash.

Beans which had not been attacked by the time of examination were classified as "Beans not injured" even when they did not germinate.

Experiment 3. Carried out in the spring of 1931. The conditions under which the experiment was carried out were the same as in last experiment. The results are shown in Table XXI.

Table XXI.

Experiments with Repellents. (iii.)

Plots	Total Number of Beans examined	Number of Beans germinated	Number of Beans injured	Per cent of Beans injured	Number of Maggots in wormy Beans
Sand treated with Creosote Oil	377	329	30	7.9	21
Desin	322	261	41	12.4	49
Creosote Emulsion	374	295	32	8.5	30
Covered with Newspaper	373	339	23	6.1	31
Check	358	195	194	54.1	447

Remarks: 1.5 litres of fine sand which was impregnated with water were thoroughly mixed with 150 cc. of crude creosote oil.

Creosote emulsion was used at a dilution of 5 times the volume of the stock solution. The formula for the stock solution: Crude creosote oil 1.8 litres, Marseilles soap 56.3 grams, water 1.8 litres.

Desin was used at a dilution of 30 times the volume of the original fluid.

Experiment 4. Carried out in the spring of 1931. In the case of substances in powder form, 150 grams were mixed with 1.5 litres of fine sand and strewn upon the field. Sand was strewn over the field in a layer about 3 centimeters in thickness. The results are shown in Table XXII.

Table XXII.

Experiments with Repellents. (iv.)

Plots	Total Number of Beans examined	Number of Beans germinated	Number of Beans injured	Per cent of Beans injured	Number of Maggots and Pupae found in or around the wormy Beans
Leucothoe and Sand	596	490	20	3.3	21
Sand treated with Creosote Oil	595	502	42	7.3	43
Desin	542	383	23	4.2	29
Dry Sand	599	115	66	11.0	134
Naphthalene and Sand	720	531	32	4.4	35
Creosote Emulsion	646	473	60	9.2	28
Kerosene and Sand	670	551	53	7.9	54
Covered with Newspaper	599	506	55	9.1	50
Check	666	482	67	10.6	51

Remarks: Desin.....30 times the original fluid.

Mixture of Leucothoe and sand.....Leucothoe powder 150 grams and sand 1.5 litres.

Mixture of naphthalene and sand.....naphthalene 150 grams and sand 1.5 litres.

Sand treated with creosote oil.....1.5 litres of sand which was moistened with water was mixed with 150 cc. of crude creosote oil.

Kerosene and sand.....1.5 litres of wet sand was mixed with 150 cc. of kerosene.

Creosote emulsion was used at a dilution of 5 times the stock solution.

Experiment 5. Carried out in the autumn of 1931. Size of one plot 1/4 *tsubo*; creosote oil, coal-tar and Leucothoe powder were used, each in combination with 1 litre of fine sand. The results are shown in Table XXIII.

Table XXIII.

Experiments with Repellents. (v.)

Plots	Total Number of Beans examined	Number of Beans injured	Number of Maggots in wormy Beans	Per cent of Beans injured
Desin	314	34	51	10.8
Sand treated with Creosote Oil	332	26	36	7.8
Coal-tar and Sand	241	18	25	7.4
Leucothoe and Sand	238	43	84	18.0
Creosote Emulsion	273	3	3	1.0
Check	320	70	131	21.8

Remarks: Desin.....70 times the original liquid; one litre per 1/4 *tsubo*.
Sand treated with creosote oil.....100 cc. of crude creosote oil for one litre of wet sand.
Coal-tar and sand.....100 cc. of coal-tar for one litre of sand.
Leucothoe and sand...70 grams of Leucothoe powder for one litre of sand.
Creosote emulsion.....at a dilution of 15 times the stock solution; one litre per 1/4 *tsubo*.

Experiment 6. May, 1932. The results are shown in Table XXIV.

Table XXIV.

Experiments with Repellents. (vi.)

Plots	Total Number of Beans examined	Number of Beans injured	Number of Maggots in wormy Beans	Per cent of Beans injured
Desin	244	25	17	10.2
Creosote and Sand	364	24	12	6.6
Coal-tar and Sand	373	4	12	1.0
Leucothoe	350	100	188	28.5
Potassium Cyanide Solution	338	37	41	10.9
Check	375	103	219	27.4

Remarks: Desin.....20 times the original liquid; 1 litre per plot.
Creosote and sand.....creosote oil 50 cc., wet sand 1 litre; one litre per plot.
Coal-tar and sand.....coal-tar 50 cc., wet sand 1 litre; one litre per plot.
Leucothoe.....70 grams per plot.
Potassium cyanide.....at a concentration of 1%; one litre per plot.

Experiment 7. May, 1932. The results are shown in Table XXV.

Table XXV.

Experiments with Repellents. (vii.)

Plots	Total Number of Beans examined	Number of Beans injured	Number of Maggots in wormy Beans	Per cent of Beans injured
Potassium Cyanide Solution	368	8	9	2.2
Creosote and Sand	350	10	7	2.8
Coal-tar and Sand	329	21	24	6.3
Check	338	32	47	9.4

Remarks: Potassium cyanide.....at a concentration of 0.5%; one litre per plot.
Creosote and sand.....creosote oil 20 cc., sand one litre.
Coal-tar and sand..... coal-tar 20 cc., sand one litre.

Discussion. The experiments described above were carried out primarily with a view to finding a substance which prevents the adult insects from depositing their eggs. All substances were applied upon the surface of the soil, therefore, they would naturally be unable to protect the seed in the soil from the attack of the seed-corn maggots which were already present in the soil. The soil of the experimental field must have contained a considerable number of maggots during the active season of the seed-corn maggot. These maggots sometimes caused a considerable amount of injury on beans even when the substances used had a repellent action to the female of the seed-corn maggot. This phenomenon was often encountered when germination was retarded or when examination of beans in an experimental plot was made too late. On account of this circumstance, results of similar experiments were sometimes found to differ slightly, especially during the season in which active adults were not numerous.

The amount of injury to soy-beans varied to some extent even when they were planted at approximately the same time. While in some experiments a fairly heavy injury resulted, the damage in others was found to be rather slight. This variation in the extent of damage was considered to be due to the number of active flies present, which varied according to the environmental conditions existing at the time the seeds were planted, such as weather, the moisture content of the soil of the experimental field, etc.

The number of injured beans might be expected to be proportional, at least roughly, to the total sum of: the number of maggots feeding in beans, the number of maggots found near sprouting beans and also the number of pupae which were found around the beans. In reality, however, it was often observed that these two factors were not proportional. Therefore, in order to evaluate the result of an experiment, these two factors, namely the number of injured

beans and the total sum of the maggots and pupae found, must be treated separately and each factor must be given due consideration.

According to Table XIX, the percentages of injured beans were fairly high in all experiments except one in which no human manure was used. Therefore, the substances tested did not seem to have exerted any repellent action to the adult of the seed-corn maggot. Probably the amount of substances used was too small in some experiments, while in others the concentration of the solution at which the substances were used was too weak to repel the adult insect. Cresol soap seemed to have had a slight power of attractiveness to the adult of the seed-corn maggot. The damage by the seed-corn maggot was very small when the human manure was not used as is evident from the results shown in Tables XIX and XX. According to Table XX, covering of the surface of the field with newspaper greatly reduced the injury. A similar result was obtained in *Experiment 3*, the results of which are shown in Table XXI. In *Experiment 4*, the results of which are shown in Table XXII, the percentage of injury was fairly high even when newspaper covers were used. The reason for this contradiction in the results obtained seems to have been that, in *Experiment 4*, the time of examination, i. e., the time the newspaper covering was taken off, was too late and the injury was thus increased since the sprouting soy-beans which remained under the newspaper attracted many maggots which were in the soil.

According to Table XX, a mixture of pyrethrum powder and ash, and also that of tobacco powder and ash, seemed to be fairly effective for preventing the flies from depositing eggs. An experiment which was carried out in the autumn of 1930, the result of which was not included in the table, showed that a mixture of pyrethrum or tobacco and ash in proportion of 1 : 2 in weight had a considerable repellent action when it was used at a rate of about 1 kilogram per *tsubo*.

A mixture of naphthalene and ash in the ratio of 1 : 2 in weight had a considerable repellent action (Table XX) as has already been demonstrated by other workers on this insect.

GOTO's desin had a fairly strong repellent action when it was used at a dilution of 50 times the volume of its original liquid and at a rate of about 1.5 litres per *tsubo*. However, it must be borne in mind that germination of beans was greatly injured when a large quantity of desin diluted to 50 times its original volume was sprayed upon the soil.

A mixture of 50—100 cc. of creosote oil and 1 litre of wet, fine sand were strewn upon the soil. The result showed that this mixture could prevent the deposition of eggs when 2 litres or more of the mixture were used per *tsubo* (Tables XXI, XXIII and XXIV). Creosote oil emulsion was also effective in preventing oviposition when it was used at a dilution of 10—15 times the volume of the stock solution (Tables XXI and XXIII).

Coal-tar was also tested since it was often used as a repellent. It showed a marked repellent action towards the adult insect of the seed-corn maggot when a mixture of 50—100 cc. of coal-tar to 1 litre of wet, fine sand was strewn over the field at a rate of 4 litres per *tsubo*.

Powdered Leucothoe leaves were tried, but no repellent action was observed.

A 0.5 per cent solution of potassium cyanide was sprayed upon the field at a rate of about 4 litres per *tsubo*, and the result showed that it had a slight repellent effect.

It has been maintained by some entomologists that dry sand reduces the injury by the seed-corn maggot if it is strewn over the field to make a layer of considerable thickness. The results obtained by the writers did not seem to support this view. When the layer of sand on the surface of the soil was very thick, germination of beans as well as the growth of seedlings was affected considerably (Table XXII). A similar result was obtained by the Miyazaki Agricultural Experiment Station.

Summarizing the results obtained by the writers, the following conclusions may be drawn: To avoid manuring with human excreta and to cover the surface of the field with newspapers or some cloth are two effective measures of reducing the damage caused by the seed-corn maggot. However, the latter method retards the germination of seeds and the growth of seedlings and it may sometimes increase the damage secondarily. Desin, emulsion of creosote oil, mixture of creosote oil and fine sand and also mixture of coal-tar and fine sand reduce the injury to from one-half to one-tenth of the damage in the check plot, if they are sprayed or strewn over the field in sufficient quantity at a proper dilution.

The writers' experiments were carried out on a rather small scale with soy-beans. Further experiments on a practical scale, using other kinds of seed such as water-melon, squashes etc., are necessary in order to determine more definitely the effectiveness of these substances as well as to study the economic aspect of these measures.

2.) *Method of repelling the larva.*

Seed treatment was often tried by entomologists to protect the seed from attack by the seed-corn maggot, but the results obtained as to the effectiveness of this method do not agree well. Therefore, the writers carried out some experiments in order to learn whether this method is effective for repelling the seed-corn maggot.

Soy-beans were used as test material and such substances as have been claimed by investigators as being effective for protecting seeds as well as those substances which have been proved by the present writers to be effective for preventing the adult from depositing eggs were tested. The experiments carried out are briefly described below.

Experiment 1. This experiment was carried out in the spring of 1931. All experimental plots were manured with human manure just as in previous series of experiments. Beans which were planted in the control plot did not receive any treatment. The substances which were tested in this experiment were coal-tar, creosote oil, desin and powdered Leucothoe leaves. Beans which were dipped in

coal-tar and taken out immediately after did not germinate for a fairly long time although most of them remained alive. When the original liquid of desin was used, not only was the germination of beans which were dipped greatly retarded, but a considerable portion of them were killed. In order to use powder of Leucothoe leaves, beans were first dipped in water and the wet beans were then mixed with the powder until their surface was covered with it.

The results of the experiment are given in Table XXVI.

Table XXVI.

Treatment of Seeds. (i.)

Plots	Total Number of Beans examined	Number of Beans germinated	Number of Beans injured	Number of Maggots in wormy Beans	Per cent of Beans injured
Check	368	350	110	49	30.3
Coal-tar	264	0	150	357	56.8
Creosote Oil	343	197	227	671	66.1
Desin	201	8	118	444	58.7
Leucothoe	230	223	121	17	52.6

Remarks: "Germinated" refers to the seeds which germinated and the seedlings appeared above the soil surface.

To treat beans with liquid substances, beans were dipped for a short time in undiluted test liquid.

Experiment 2. This was carried out in the autumn of 1931. Generally, the majority of soy-bean seeds do not germinate after they have passed the summer. Therefore, in the present experiment the number of beans which germinated was

Table XXVII.

Treatment of Seeds. (ii.)

Plots	Total Number of Beans examined	Number of Beans injured	Number of Maggots in wormy Beans	Per cent of Beans injured
Check	134	54	103	40.2
Coal-tar	154	68	117	44.1
Desin	179	64	127	35.7
Leucothoe and hydrated Lime	175	62	106	35.4
Creosote Emulsion	155	23	27	14.8

Remarks: Leucothoe and hydrated Lime.....Equal weights of these two substances were mixed together and wet beans were rolled over the mixture.

Desin.....at a dilution of 70 times the original liquid.

Creosote emulsion.....15 times the stock solution.

not determined. Coal-tar was tested according to a different method from that used in the last experiment; 10 cc. of coal-tar was mixed thoroughly with 200 cc. of wet, fine sand. Soy-beans were rolled over this mixture until a thin layer of coal-tar adhered to the beans. The results of the experiment are shown in Table XXVII.

Experiment 3. This was carried out in the spring of 1932. The results are shown in Table XXVIII.

Table XXVIII.

Treatment of Seeds. (iii.)

Plots	Total Number of Beans examined	Number of Beans germinated	Number of Beans injured	Number of Maggots in wormy Beans	Per cent of Beans injured
Check	361	281	80	52	22.1
Creosote Emulsion	314	243	150	457	47.7
Desin	328	291	37	29	11.2
Coal-tar	331	69	217	621	65.5
Leucothoe and hydrated Lime	362	337	79	27	20.9

Remarks: Creosote oil emulsion.....15 times the stock solution.
Desin.....70 times the original fluid.
Coal-tar.....10 cc. of coal-tar were mixed with 200 cc. of wet sand. Beans were rolled over the mixture so that they were smeared with coal-tar.

Experiment 4. Carried out in the spring of 1932. The results are shown in Table XXIX.

Table XXIX.

Treatment of Seeds. (iv.)

Plots	Total Number of Beans examined	Number of Beans germinated	Number of Beans injured	Number of Maggots in wormy Beans	Per cent of Beans injured
Check	320	260	53	130	16.5
Creosote Emulsion (i)	337	237	88	452	26.4
Creosote Emulsion (ii)	477	164	168	768	36.8
Desin	307	234	68	228	22.1
Coal-tar	344	239	100	267	29.0
Leucothoe	317	212	92	338	29.0

Remarks: Creosote emulsion (i).....30 times the stock solution.
Creosote emulsion (ii).....15 times the stock solution.
Desin.....70 times the original liquid.
Coal-tar.....10 cc. of coal-tar were mixed with 400 cc. of wet sand.

Discussion. The results given in Table XXVI indicate that the number of beans injured was greater in the plots where beans were treated with coal-tar, creosote oil or with desin than in the control plot and also that the number of maggots which were found in the wormy beans was larger in the experimental plots than in the check. This was due to the fact that when beans were treated with these substances, not only was germination markedly retarded, but a certain portion of them were killed and these beans also attracted maggots which were found in the soil. Therefore, these experiments must be excluded in considering the effectiveness of seed treatment.

According to Table XXVI, when beans were treated with Leucothoe powder the number of maggots in wormy beans was smaller than in the check, but the percentage of beans injured was higher in the experimental plot than in the check. According to Table XXIX, both the percentage of wormy beans and the number of maggots in them were larger in the treated plot than in the check. A mixture of Leucothoe powder and hydrated lime was also tested. According to Table XXVIII, the number of maggots in wormy beans was smaller in the experimental plot than in the check, but the percentage of wormy beans was nearly the same in the two plots. In Table XXVII, the percentage of wormy beans in the experimental plot did not differ much from that in the check plot and the number of maggots in the wormy beans in the two plots was nearly the same. These findings seem to indicate that the powder of Leucothoe leaves did not reduce the injury by the seed-corn maggot.

According to Tables XXVII—XXIX, treatment with coal-tar did not reduce the injury.

Desin did not injure the germination of beans when diluted to 70 times the volume of the original liquid, but treatment of beans with this substance at the strength mentioned could not reduce the injury. For instance, according to Table XXVIII, the percentage of wormy beans as well as the number of maggots in them seemed to be slightly smaller in the treated plot than in the check, but in Tables XXVII and XXIX the percentage of injured beans was either nearly the same or even higher in the treated plots than in the check. The number of maggots in wormy beans was larger in the treated plots.

According to Table XXVII, the percentage of wormy beans as well as the number of maggots in them were slightly smaller in the plot treated with creosote oil than in the check, but in the other tables just the reverse is seen.

When all these results are carefully examined, it seems possible to draw the following conclusions: None of the substances tested by the writers could definitely diminish the damage done by the seed-corn maggot. It seems, therefore, that treatment of seeds with various chemicals with the object of preventing attack by the seed-corn maggot is not promising. This may be expected when the habit of the adult insect is taken into consideration. The fly oviposits on the surface of the soil which covers the seeds, therefore whether or not seeds are previously subjected to a special treatment does not much influence oviposition by the fly. A small quantity of repellent which adheres to the seeds after the

treatment would be absorbed by the soil when they are covered with it after being planted. Therefore, the treatment would probably have little repellent action towards the maggots living in the soil. Coal-tar, desin and creosote oil emulsion retard the germination of seeds or even kill them if these materials are used at a very strong concentration. Consequently, the ungerminated seeds in the soil may attract a great many maggots living in the soil, as is evident from the results shown in Table XXVI. Attention must be paid to this point when treating seeds with the object of preventing injury by the seed-corn maggot.

III. Summary and Conclusions.

The results of experiments which were carried out in order to find suitable methods for controlling and preventing injury by the seed-corn maggot are reported in the present paper. Some of the experiments here reported are as yet preliminary in nature and further experimentation is needed to decide the practical value of the methods which have been tested.

Submergence was tried to kill the egg, larva and pupa, but the results of experiments showed that this method does not seem to be effective in controlling any of these stages on a practical scale.

Mixture of pyrethrum and soap solution, emulsion of kerosene extract of pyrethrum, cresol soap, desin, neoton, Derris soap, nicotine sulphate, lime-sulphur, tobacco powder, mixture of tobacco and wood-ash, also that of pyrethrum and wood-ash, Leucothoe powder and mixture of Leucothoe powder and wood-ash were tested in the laboratory to see whether these are effective for killing the egg, larva or pupa which is found in the soil. A few of them were fairly effective when they were tested at a highly concentrated state, but they were then injurious to soy-beans and could not be used for practical purposes. Most of the substances tested were not sufficiently toxic to warrant their use. Goro's desin was found to be toxic enough to kill the egg of the seed-corn maggot when it was used at a dilution of 1 : 50, but it was injurious to the soy-bean when it was used at this concentration. The larva could not be killed by desin even at this concentration.

The larva could possibly be killed by burying it for several days in soil which was saturated with the emulsion of kerosene extract of pyrethrum diluted to 10 times the volume of the stock solution. However, it is doubtful whether this method can be employed on a practical scale. In short, it seemed difficult to kill either the egg, or larva, or pupa which is in soil with any of the substances experimented upon by the writers.

In view of the report that a fair control of the onion maggot was obtained in foreign countries by the use of poisoned bait for the adult insect, several substances were tested for their power of attracting the adult insect of the seed-corn maggot. According to these tests, solution of ammonia and alcohol were

found to be fairly attractive. These chemicals were almost as attractive as human excreta when they were used at proper concentration. A few kinds of esters which are known to give a peculiar odour similar to that of ripening fruits or to flowers were mixed with alcohol and tested for their attractiveness. It was found that ethyl butyrate, methyl butyrate and methyl acetate did not increase the attractiveness of alcohol when they were dissolved in it.

Dried pupae of the silkworm and cotton seed meal were found to possess a remarkable degree of attractiveness to the adult of the seed-corn maggot. These two substances were markedly more attractive than either alcohol, ammonia, human excreta, or alcoholic solution of esters. It was not known what odorous substance contained in them was responsible for this remarkable degree of attractiveness. However, it was certain that the attractiveness was not due to the smell of ammonia which might be emitted from these substances. The utilization of such substances as dried pupae of the silkworm and cotton seed meal as poisoned bait for the adult insects of the seed-corn maggot would seem to be promising, since the preoviposition period of this fly is roughly from one to two weeks according to the season in which they appear.

To prevent injury by the seed-corn maggot, some method of preventing the oviposition of the adult insect and also seed treatment were tested. Although treatment of seed with coal-tar has often been recommended up to the present time, the results of the writers' experiments did not indicate the effectiveness of this method. The writers consider that the efficacy of seed treatment as a preventive measure is rather uncertain.

Various substances were tested in regard to their power of preventing the female fly from laying eggs. Mixture of pyrethrum and wood-ash, that of tobacco powder and wood-ash, and also that of naphthalene and wood-ash, were effective for preventing oviposition when sufficiently large amounts of them were strewn upon the field. Creosote oil emulsion and mixture of creosote oil and fine sand, and also that of coal-tar and fine sand, had a fairly marked effect of preventing oviposition when they were used at a proper concentration and in a sufficiently large quantity. The writers' experiments on the method of preventing oviposition were carried out on a rather small scale. Therefore, further experimentation on a larger scale is needed to determine proper quantities of substances to be used for this purpose.

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