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UNITED STATES DEPARTMENT OF AGRICULTURE

Bureau of Entomology and Plant Quarantine

RESULTS OF CODLING MOTH INVESTIGATIONS, 1939

Part II

Work Conducted by the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture.

Not for Publication

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(Not for publication)

RESULTS OF CODLING MOTH INVESTIGATIONS, 1939

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This summary represents the contribution of the Division of Fruit Insect Investigations of the Bureau of Entomology and Plant Quarantine to the pool of information on the results of codling moth investigations carried on during 1939, which has been prepared in accordance with a request made by the Committee on the Codling Moth of the American Association of Economic Entomologists. As in previous years, this is a preliminary report, circulated for the information of those interested. It is subject to revision as further review of the data may indicate, and has the status of unpublished data, not subject to quotation without permission.

The work of the Division of Fruit Insect Investigations is carried on cooperatively with several Bureau and Department units, as well as with a number of State agencies. The Division of Insecticide Investigations has contributed a great deal to the work reported herein, and joint field laboratories are maintained at Yakima, Washington, and Vincennes, Indiana. The chemists stationed at the latter laboratory have also participated to a considerable extent in the work at St. Joseph, Mo. The work in West Virginia is a joint effort carried on by the West Virginia Agricultural Experiment Station and this Bureau; the work in New York State is carried on similarly with the New York Agricultural Experiment Stations.

The Division of Foreign Parasite Introduction has continued to cooperate in the work relating to parasites. Special attention has been devoted to certain phases of the biological-mechanical control project under way in West Virginia.

ST. JOSEPH, MISSOURI

Howard Baker, In Charge

Seasonal Conditions

Temperatures which averaged above normal again for the year as a whole were near normal only in April and August and much above normal in January, May, July, September, October, and December. Rainfall was again deficient except in March, June, and November.

From the standpoint of size the crop was one of the largest ever produced in this area but from the standpoint of quality it was one of the poorest, because of high temperatures and strong, hot winds which prevailed from the last of August to the middle of September, and because of a severe attack by the third brood of the codling moth. The harvested crop lacked normal size and color and was very wormy. In addition, preharvest dropping of fruit was severe, especially of the Jonathan variety.

The codling moth population was the heaviest on record, and throughout the season conditions were ideal for almost unrestricted activity and development whenever a population of any size was present. The ten bait traps operated in and adjoining the experimental spray block caught an average of 1303 moths each during the season. This is nearly twice the number of moths caught per trap in any previous season.

Bait trap catches of spring-brood moths began May 10, reached their peak May 22, and were large during the period May 15 to June 1. Bait trap catches of first brood moths began about June 30, reached their peak July 12 and 22, and were large throughout July. Bait trap catches of second brood moths began about August 10, reached their peak August 27, and were large during the period August 22 to September 4. Only small numbers of moths were caught after September 8.

First brood worm damage was comparatively light, second brood damage was moderate to heavy, and third brood damage was generally heavy to severe. Many orchards in which it appeared that excellent control of the first brood was obtained were very wormy at the end of the season.

Field Tests of Insecticides

Tests of miscellaneous treatments

Field spray tests of insecticides for control of the codling moth were carried out in a block of trees of the Jonathan variety located near Troy, Kansas. The trees were 22 years old and had an excellent crop. Treatments 1 to 11, inclusive, were applied to 4 replications of 3 trees each while treatment 12, which was added at the time of the second cover spray application, was applied to 8 scattered trees which were somewhat smaller in size than most other trees in the experimental block. The codling moth infestation was heavy as indicated by the fact that the bait traps operated caught an average of 1303 moths each.

The entire block received a prebloom scab spray of liquid lime sulphur April 26 and a uniform calyx spray of lead arsenate, hydrated lime, and dry lime sulphur May 9. The experimental treatments were applied in seven cover sprays as follows: 1st cover - May 22,23; 2nd cover - May 31; 3rd cover - June 12; 4th cover - July 3; 5th cover - July 14; 6th cover - July 31; and 7th cover - August 17. Harvest was started September 5 and completed September 16.

The treatments tested and the results effected by them are given in table 1. Table 1 follows with the treatments listed in order according to the total number of worms permitted per 100 apples.

Table 1. Results of Field Experiments for Codling Moth Control, St. Joseph, Mo., 1939.

Plat No.	Treatment* (Quantities for 100 gallons unless otherwise stated)	Apples per tree	Percent Clean	Total per 100 apples Worms	Total per 100 apples Stings
5.	Tank-mix nicotine bentonite; nicotine sulphate (40% nicotine) 1 pint, bentonite 5 lbs., sodium lauryl sulphate 1/2 oz., and soybean oil 1 qt.	2299	82.1	14.2	6.3
4.	Lead arsenate + hydrated lime or Bordeaux mixture as in Plat 1 + soybean flour 1/4 lb.	1865	69.5	15.9	25.9
3.	Lead arsenate + hydrated lime or Bordeaux mixture as in Plat 1 + mineral (summer) oil 3 qts. in 3rd and 5th covers.	2124	67.6	17.8	28.3
2.	Lead arsenate + hydrated lime or Bordeaux mixture as in Plat 1 + mineral (summer) oil 3 qts. in 3rd cover.	2402	62.2	22.5	35.6
6.	Tank-mix nicotine bentonite as in Plat 5 except nicotine and bentonite reduced one-half in 5th, 6th, and 7th covers.	1943	74.4	23.2	7.8
1.	Lead arsenate 3 lbs.,+ hydrated lime 3 lbs. in 1st and 4th covers; lead arsenate 4 lbs.+ hydrated lime 4 lbs. in 2nd and 3rd covers; lead arsenate 3 lbs.+ Bordeaux mixture 3/4-1 1/2-100 in 5th, 6th, and 7th covers.	2168	58.2	24.5	41.1
12.	Lead arsenate + hydrated lime or Bordeaux mixture as in Plat 1 + brown sugar 8 lbs. in 2nd to 7th covers, inclusive	930	57.0	25.1	42.5
8.	Tank-mix nicotine bentonite as in Plat 5 in 1st 4 covers; nicotine sulphate (40% nicotine) 2/3 pint, + bentonite 1 lb., + mineral (summer) oil 2 qts. in 5th, 6th, and 7th covers.	1777	71.6	25.8	8.8
11.	Tank-mix nicotine bentonite as in Plat 6 with sodium lauryl sulphate omitted from all applications.	1999	71.9	26.9	7.6
7.	Tank-mix nicotine bentonite as in Plat 5 in 1st 4 covers; processed nicotine bentonite (4.75% nicotine) 4 lbs. + mineral (summer) oil 2 qts. in 5th, 6th, and 7th covers.	2150	70.7	29.4	7.6
9.	Processed nicotine bentonite (4.75% nicotine) 8 lbs. in 1st cover; 6 lbs. + mineral (summer) oil 2 qts. in 2nd to 7th covers.	1916	63.3	36.5	9.4
10.	Processed nicotine bentonite (4.75% nicotine) as in Plat 9 in 1st 4 covers; 4 lbs. + mineral (summer) oil 2 qts. in 5th, 6th, and 7th covers.	1940	52.6	52.7	11.2

* Wettable sulphur, 5 lbs., was used with all treatments in the 1st cover for scab control and soybean oil was omitted from the tank-mix nicotine bentonite treatments.

Difference required for significance: 10.09 P=.01; 7.62 P=.05

Spray deposits

Analyses of the spray deposits on stratified samples of fruit taken from the several plats before and after each cover spray and at harvest beginning with after the first cover spray were made by Mr. Jack Fahey of the Division of Insecticide Investigations, Vincennes, Ind. laboratory. In general there was a close correlation between the amount of the spray deposit that was built and maintained and the degree of control effected by the several treatments.

Injury to fruit and foliage

None of the materials or combinations of materials tested caused any noticeable injury to fruit or foliage that was worth noting. However, a comparison of the size of the fruit harvested from the several plats, based on the number of apples per bushel, showed some variation that may have been associated with the treatments. In a general way the size of the fruit was inversely proportional to the efficiency of the treatment. The average number of apples per bushel is given below for each treatment except number 12 which is not comparable with the others.

Treatment number*	Number of apples per bushel	Treatment number	Number of apples per bushel
9	195	3	215
10	200	2	217
1	202	6	225
7	209	4	237
8	210	5	241
11	211		

* For complete record of treatment see table 1,

Spray residues

Analyses made by Mr. Fahey of the Vincennes, Ind. laboratory indicated that lead arsenate residues were removed satisfactorily by a moderate washing treatment except in the case of treatment 3 in which oil was used in one second brood application. It appears therefore that oil may be used in this area with lead arsenate in first brood applications without unduly complicating the removal of lead and arsenic residues and that it cannot be so used in later applications without complicating the removal of such residues.

Nicotine residues are important chiefly from the standpoint of the extent to which they detract from the appearance of marketed fruit. In our plats residue on fruit from plat 5 was heavy and unsightly, that on fruit from plats 6 and 11 was less but still moderately heavy and unsightly, that on fruit from plats 7 and 8 was light and not especially objectionable, and that on fruit from plats 9 and 10 was hardly noticeable. Samples of fruit from plats 5,6,7,8, and 11 were wiped in two types of wipers, (1) an old style cloth wiper, and (2) a modern wiper equipped with No. 10 grooved brushes and capable of handling about 500 bushels of fruit daily. The old style cloth wiper did not do a satisfactory job in any instance. The modern brush wiper cleaned the residue from fruit from plats 7 and 8 equally well and thoroughly when operating at capacity, it did not clean the residue from fruit from plats 6 and 11 satisfactorily when operating at capacity but did a good job, except for the stem and calyx ends, when operating at one-half of capacity, and it did not clean the residue from fruit from plat 5 sufficiently well to make it attractive for marketing. Residue on Winesaps which had received treatment 5 was hardly touched by the brush wiper. Washing tests were not attempted for the reason that it has already been demonstrated that an efficient washing treatment will remove nicotine residues satisfactorily regardless of treatment or variety.

Triple-action spray block

The triple-action spray program which involves the use of lead arsenate, oil, and nicotine in combination for control of the first brood was tested in a 24-year-old block of trees 18 rows wide by 29 to 40 trees long which provided two replications of Delicious and one of Jonathan. The following three treatments, each 18 rows wide, were set up in this area; (1) 15 trees long in which nicotine was used at the rate of 1 pint per 100 gallons of spray, (2) 8 to 19 trees long (only 2 outer rows less than 12 trees long) in which nicotine was used at the rate of 1/2 pint per 100 gallons of spray and, (3) a check 6 rows long in which no nicotine was used. The check treatment was similar to that used by the grower on his entire acreage. The prebloom and calyx sprays were applied uniformly to the entire block by the grower. The experimental treatments were confined to the three first brood cover sprays that were applied with our assistance and under our supervision. The grower applied four later cover sprays uniformly to the entire block. These later cover sprays contained lead arsenate but no nicotine or oil. Special attention was given to hitting the tops of the trees with the spray first and to getting a thorough coverage of the entire tree. Dead moths were captured on canvas covers placed beneath some of the trees as they were sprayed and practically no insects that were identified as codling moths flew from the trees at the time of spraying. The detailed program applied as treatment 1 was as follows: 1st cover (May 19), lead arsenate 3 lbs., hydrated lime 3 lbs., nicotine sulphate (40% nicotine) 1 pt., and wettable sulphur 3 lbs. plus water to make 100 gallons of spray; 2nd cover (May 29), lead arsenate 3 lbs., hydrated lime 3 lbs., free nicotine (50% nicotine) 1 pt., soybean flour 1/4 lb., plus water to make 100 gallons of spray; and 3rd cover (June 9), lead arsenate 3 lbs., nicotine sulphate (40% nicotine) 1 pt., mineral (summer) oil 11/16 gal. plus water to make 100 gallons of spray. Treatments 2 and 3 were similar to treatment 1 except as mentioned previously. It was unfortunate that it was not safe to include oil in the program until near the end of first brood activity but that is a condition that would prevail more often than not in this section and will in all likelihood continue to prevail until such time as a satisfactory fungicide is developed which can be used safely with oil or followed by it at a short interval. Thus, the program tested was more a double-action than a triple action one.

The degree of control of the codling moth found to obtain in this block at the end of the period of first brood activity is given in table 2.

Table 2. Control of First Brood of Codling Moth by Triple-action Spray Program as Indicated by Drop and Stratified Samples of Tree Fruit Examined at the End of the Period of First Brood Activity, Wathena, Kansas, 1939.

Treat-ment	No. of trees	Tree fruit-stratified sample				Total worms per 100 apples		
		Total fruit	Percent of fruit			Tree sample	Drop fruit	All fruit
			Clean	Wormy*	Stung			
1.	15	3000	95.5	0.8	3.8	0.8	0.7	1.5
2.	15	3000	94.0	1.3	4.8	1.3	0.7	2.0
3.	15	3000	93.5	1.4	5.6	1.5	0.7	2.2

* Analysis of variance indicated that the difference between treatments in percent of wormy fruit was not significant.

The degree of control of the codling moth found to obtain in this block at the end of the season and including fruit that dropped during the season is given in table 3.

Table 3. Control of Codling Moth in Triple-action Spray Block, Wathena, Kan., 1939

Treat-ment	Number of trees	Apples per tree	Percent clean fruit	Total per 100 apples	
				Worms	Stings
1.	15	4429	56.8	40.8	25.9
2.	15	4235	52.2	48.3	26.7
3.	15	4977	55.0	41.4	27.6

The Jonathan harvest began September 4 and was completed September 18 while the Delicious harvest began September 21 and was completed September 27. The small number of stings in proportion to the number of worms is taken as an indication of the potency of the third brood and the fact that the young worms of that brood apparently made entrance into the fruit without difficulty despite the fact that the last spray application was not made until August 16. It is believed that that part of the block assigned to treatment 1, in which nicotine was used at the rate of 1 pint per 100 gallons of spray during the period of first brood activity, has been wormier than the remainder of the block in previous years. For this reason treatment 1 should probably be given credit for a better showing than the results indicate.

Miscellaneous Studies

Protection of trees against injury by treated bands

A number of materials were tested in 1937 and 1938 for their ability to protect smooth-barked scaffold limbs against the injury that ordinarily results from the application of chemically-treated bands to them. In these tests, paraffin gave a high degree of protection and was superior to other materials tested. There was some evidence that the paraffins with the higher melting points were slightly superior to those with the lower melting points. These tests were continued in 1939 on smooth-barked limbs ranging in diameter from 3.8 to 7.0 inches using paraffins of known melting points alone and in combination with beeswax and bentonite. A high degree of, but not perfect, protection was secured in all cases. In all likelihood the injury that did occur would be considered serious by the average grower though in most instances it was slight. The melting point of the paraffins tested ranged from 45 to 56-58°C. but each gave about the same degree of protection. Paraffin mixed with beeswax was not as satisfactory as paraffin alone but mixed with bentonite gave evidence that such a combination might be slightly superior to paraffin alone.

Catch of larvae in bands

A comparison of the number of larvae caught in untreated 2" corrugated paper bands applied to the trunks of 30 24-year-old Jonathan trees in a small isolated orchard with the number that matured and left the fruit was made. With one exception the same 30 trees were used as were used in a similar test in 1938. In 1938 the 30 record trees produced an average of 1927 apples and 1081 mature larvae that exited from the fruit of which an average of 125, or 11.6%, were caught in the bands. In 1939 the 30 record trees produced an average of 3894 apples and 1995 mature larvae that exited from the fruit of which an average of 260, or 13.0%, were caught in the bands.

A comparison of the recovery of liberated marked larvae in untreated 2" corrugated paper bands applied to trunks was made on trees classified according to size. A total of 1720 larvae was liberated on the ten trees included in each of three size groups, size being determined on the basis of the amount of ground area covered by the spread of the tree branches. On small trees, whose average ground area beneath the spread of branches was 251 square feet, 15.1 percent of the liberated larvae were recovered; on medium sized trees, whose average ground area was 399 square feet, 10.5 percent of the liberated larvae were recovered; and on the larger trees, whose average ground area was 603 square feet, 6.6 percent of the liberated larvae were recovered. As expected, recoveries were in inverse ratio to the size of the trees.

Survival of mature codling moth larvae and effect of scraping and banding on same.

The studies of the proportion of the mature larvae that survive after leaving the fruit, reported on previously, have been continued. In corroboration of the results as reported in previous years, it was found (1) mortality of the codling moth is heavy between the time that it exits from the fruit as a mature larva and emerges as a moth, (2) scraping of trees has little effect on the percentage of transforming larvae that may develop into moths but results in a material reduction in the percentage of non-transforming larvae that enters hibernation, and (3) banding of scraped trees results in a sharp reduction in both the number of larvae that would otherwise develop to emerge as moths during the current season and the number that enters hibernation.

Moth emergence, bait trap catches, and egg deposition

A study was started of the relationship of moth emergence to moth activity and egg deposition. There was a close correlation between the time that moths emerged and the time that eggs were deposited and between the number of moths that emerged and the number of eggs deposited throughout the season. Undoubtedly this correlation was aided by the favorable weather for moth activity that prevailed almost without interruption whenever moths were present in any number from the time they first emerged until after the middle of September. The peak catch of spring-brood moths forecast the time of maximum deposition of first brood eggs, the peak catch of first brood moths followed after the time of maximum deposition of second brood eggs, and the peak catch of second brood moths coincided with the time of maximum deposition of third brood eggs. A marked rise in catches of first and second brood moths did not occur until after second and third brood eggs were found deposited in increased numbers but the lag was not so great but that sprays applied according to the indications of the bait trap catches were put on in time for the first worms of these broods that hatched. The number of moths caught in the bait traps did not indicate the relative numbers of eggs deposited. The catch of spring-brood moths, particularly, was out of line with the number of moths that emerged and the number of eggs deposited as compared to the relationship that existed the remainder of the season.

MOORESTOWN, NEW JERSEY

H. W. Allen, In Charge

Parasite Investigations

One additional release of the Australian codling moth parasite, Gambrus stokesii Cwfd., was made near Geneva, N.Y., in cooperation with the New York Agricultural Experiment Station. The colony consisted of 137 males and 149 females.

GENEVA, NEW YORK

D. L. Collins, In General Charge
William Machado, In Immediate Charge

Light and Bait Trap Studies

The field experiments in the McIntosh orchard for the season of 1939 were enlarged, and arranged on a plan which differed somewhat from that used in 1938. The two areas with light traps remained as before, except for a difference in spray treatment, but the baited area was enlarged to include all but 10 of the trees in the rest of the orchard. This increase in the number of bait traps was undertaken primarily as a means of inhibiting the movement of the moths from other parts of the orchard into the experimental areas. It was also thought that the placing of bait traps in all of the remaining trees in the orchard would give some indication of the distribution of the adult population of moths.

Most of the spraying was done by the owner of the orchard, who made three cover applications. The workers of the Station, however, applied the sprays to five trees in each lighted or baited block, and to ten trees in the block where no traps were maintained. Only two cover sprays were applied to these trees. A number of trees had rather short crops, and were not included in the final infestation records.

The light traps used were of the electrocuting type, were equipped with 100-watt, type A, Mazda lamps, and were hung as near as possible to the top and center of the tree. The bait traps used were the same type as those used in 1938, consisting of a pair of glass quart jars filled with baits of different ages. Fermenting coarse brown sugar syrup with oil of sassafras emulsion, as recommended by Mr. L. F. Steiner, was used as the bait. The formula required four pounds, two ounces of brown sugar to five gallons of water. To this was added 10 cc of natural oil of sassafras and 40 cc of water, the oil being emulsified with sodium lauryl sulfate. The bait in one of the jars was changed each week so that a more or less constant state of fermentation could be maintained. A pair of jars was placed as near the top and center of the tree as possible.

Untreated bands were maintained on the trees, which had previously been scraped. Daily counts of the catches in the light traps were made, but due to the large number of bait traps, these traps were examined approximately only every other day. All drop apples were systematically counted and examined for codling moth injury and removed from the orchard. At the harvest, two random bushels from each of the count trees were picked, counted and examined for injury. Counts of the total number of bushels from every tree were made and these figures were used in calculating the total crop.

The results of this work are summarized in table 1, which follows:

Table 1. Results of Bait and Light Trap Experiments, Geneva, N.Y., 1939.

Plat	Treatment	Number of trees in block	Number of count trees	Moths caught per trap: In bait traps	Moths caught per trap: In light traps	Larvae taken in bands per tree	Injuries per 100 apples: Deep injuries (worms)	Injuries per 100 apples: Stings	Clean Apples
A	Lights - 2 cover sprays (station)	5	4	---	10.6	13.0	5.2	5.4	91.5
B	Lights - 3 cover sprays (grower)	20	11	---	16.1	16.9	14.0	9.6	81.3
C	Lights & baits - 2 cover sprays (station)	5	5	7.2	14.4	5.2	5.8	8.3	89.1
D	Lights & baits - 3 cover sprays (grower)	20	18	2.5	21.2	10.4	8.9	6.5	87.8
E	Baits - 2 cover sprays (station)	5	1	17.2	---	39.2	27.9	20.2	64.6
F	Baits - 3 cover sprays (grower)	116	25	22.9	---	45.5	38.2	13.9	60.2
G	Two cover sprays only (station)	10	10	---	---	42.7	33.2	17.5	62.1

As in 1938, the bait traps captured a higher percentage of female moths than the light traps. In 1939, the figures were: bait traps 78.0% females; light traps 28.7% females.

GENEVA, NEW YORK

D. M. Daniel, In Charge

Biological-Mechanical Control

A new project on biological-mechanical control has been undertaken in western New York. This is a joint effort carried on cooperatively by the New York State Agricultural Experiment Station and the Bureau of Entomology and Plant Quarantine. This project is in many respects parallel to the cooperative biological-mechanical control project that has been under way in West Virginia for several years. It is also an outgrowth of experiments that have been carried on by the Geneva Station since 1930. Those studies (Cox and Daniel, Jour. Econ. Ent. 28:113, 1935) showed that, for a period of four years, the average percentage of parasitism in unsprayed orchards was more than twice that in sprayed orchards. They also showed that the parasite, Ascogaster, when exposed to foliage sprayed with arsenicals lived one-half as long and parasitized one-half as many codling moth eggs as those exposed to clean foliage, and that parasitized larvae were no more susceptible than normal larvae to sprayed fruit. These experiments pointed the way to a general consideration of the effects of orchard practices on all the biological control factors operating on the codling moth.

Two somewhat similar orchards have been selected in the midst of the most severely infested area in western New York. One of these is receiving no lead arsenate sprays, although necessary fungicides are being applied for the control of diseases. The second orchard is divided into four blocks, one of which is receiving only fungicide sprays; one the regular schedule of lead arsenate; one a fixed nicotine program and the fourth a xanthone schedule. This planting in its entirety is used as a sprayed check on the orchard receiving no insecticide applications.

The records obtained in 1939 will serve as a base line from which to judge the relative trends in the two orchards in subsequent seasons. Detailed figures will not be given at this time.

One interesting development was the finding of about 62 percent parasitism by Trichogramma in eggs on the fruit in the biological-mechanical control orchard at picking time. No such parasitization developed in the sprayed orchard.

POUGHKEEPSIE, NEW YORK

P. J. Chapman, In General Charge
D. W. Hamilton, In Immediate Charge

Seasonal Conditions

Codling moth injury during 1939 was more severe with serious injury occurring in a larger number of orchards in the Hudson River Valley than at any time during the previous decade. While many factors contributed to this increase in infestation some of the outstanding ones were (1.) Mean temperatures during June, July, and August were above normal which created a more ideal temperature for oviposition and codling moth activity and lengthened the period of attack. (2.) Rainfall was below normal averaging 12.03 inches from May 1 to September 30, as compared to 38.13 inches during the same period in 1938. (3.) Trees in many of the orchards have become mature, are more difficult to spray properly, and have more ideal places for larvae to hibernate in. (4.) A mild winter during 1938-39 caused a low mortality rate among overwintering larvae.

As indicated by bait traps spring brood moth activity began May 23 at Poughkeepsie, and May 25 at Kinderhook. Peak captures of spring-brood moths occurred May 27 to June 1, with moderately heavy adult activity continuing through June. Captures between July 1 and July 15 were comparatively light indicating the end of spring-brood activity. Peak captures of first-brood moths occurred July 31 to August 2, with comparatively heavy captures occurring from July 23 to August 13. No adults were captured in the traps during September.

Larval entrances were first found at Poughkeepsie June 6, and at Kinderhook June 7. Two McIntosh trees near Poughkeepsie were left unsprayed after May 31, and the injured apples removed at 7-day intervals. Less than 13 percent of the total season's injury occurred during the first-brood period. About 70 percent of the injury for the season was recorded during August, which indicates the severity of the attack by second-brood worms. Much of the injury took place after the application of the last spray for the season.

Insecticide Experiments

Field tests of insecticides for codling moth control were conducted in an orchard near Poughkeepsie. In addition to these tests a 3-acre demonstrational block using one of the more promising schedules was maintained in a severely infested orchard near Kinderhook. As in the past few years, emphasis was placed on schedules that avoided objectionable residues at harvest and that offered protection for apple maggot as well as codling moth.

Tests at Poughkeepsie:-

Fourteen spray programs, with various materials, were tested in two-tree plots, replicated four times. (table 1). The variety used was Cortland. Two programs comparing fixed nicotines were tested on single-tree plots replicated five times (table 2). These trees were also Cortlands. Two programs comparing the effect of sugar when added to stomach poisons were tested on two-tree plots replicated four times (table 3). The variety used was Rome Beauty.

A calyx treatment consisting of lead arsenate 3 pounds, hydrated lime 3 pounds, dusting sulfur 4 pounds, and skim milk 1/4 pound was applied to all the trees May 22. A curculio spray of the same materials was applied May 31. During first brood the first cover spray was applied June 9. The second cover spray was applied June 22 on all plots except 11 to 14, which had the second cover applied on June 19. The third cover spray was applied July 12 on all plots except 11 to 14, which were sprayed July 1. A fourth cover spray was applied to plot 12 July 12. During second brood the first second-brood spray was applied August 2 except on plots 15 and 16 which were sprayed August 10. The second second-brood spray was applied to all plots except 15 and 16 on August 12.

A summary of the materials used and results obtained are presented in tables 2, 3, and 4.

Table 1. Results of Experiments with Insecticides for Codling Moth Control
Poughkeepsie, N.Y.-1939 Var. Cortland

Plot No.	Materials Applied in Cover Sprays (Quantities per 100 Gallons)	Apples per Tree	Injuries per 100 Apples		Apples Clean	Harvest Residues **	
			Worm Holes	Stings		As_2O_3	Pb.
					percent	gr/lb	gr/lb
1.*	No second brood cover	3363	22.5	18.4	75.2	0.012	0.012
2.*	Processed nicotine bentonite 8 lbs. 2 covers. 2nd brood	2895	15.3	14.4	80.4	.011	.010
3.*	Processed nicotine bentonite 8 lbs., 1st cover 2nd brood. Nicotine sulfate 1 pt., summer oil 3 qts. 2nd cover 2nd brood	2789	15.6	17.8	78.6	.012	.011
4.*	Nicotine sulfate 1 pt., summer oil 3 qts., 2 covers, 2nd brood	2973	16.8	17.3	78.6	.013	.009
5.*	Processed nicotine bentonite 4 lbs., summer oil 3 qts., 2 covers 2nd brood	2351	14.2	12.6	82.2	.013	.011
6.*	Xanthone 2 lb. hydrated lime 3/4 lb. tar soap 1 lb. 2 covers 2nd brood	2811	13.3	18.8	78.5	.016	.012
7.*	Proprietary material containing 10% derris resins, 10% pine oil, 25% ethanolamine soap. 1/2 gal. 2 covers 2nd brood	3031	17.9	16.8	79.1	---	---
8.*	Summer oil 3 qts. 2 covers 2nd brood	2759	20.4	16.4	78.2	--	--
9.*	Processed nicotine 4 lbs. summer oil 3 qts. 2 covers 2nd brood	3560	17.0	14.7	80.2	.013	.009
10.*	Nicotine sulfate 1/2 pt. summer oil 3 qts., 2 covers 2nd brood	3038	14.6	15.2	81.0	--	--
11.	Nicotine sulfate 1 pt. bentonite 5 lb., sulfur 4 lb. 1st cover. Nicotine sulfate 1 pt., bentonite 5 lb., soybean oil 1qt. 2nd, 3rd, and 1st 2nd-brood covers. Nicotine sulfate 3/4 pt., summer oil 3 qts. 2nd 2nd-brood cover.	2756	11.5	11.3	83.1	--	--

Table 1. (Cont'd) Results of Experiments with Insecticides for Codling Moth Control
Poughkeepsie, N.Y. - 1939 Var. Cortland

Plot No.	Materials Applied in Cover Sprays (Quantities per 100 Gallons)	Apples per Tree	Injuries per 100 Apples: Worm Holes	Stings	Apples Clean	Harvest Residues**: As_2O_3	Pb.
					percent	gr/lb	gr/lb
12	Lead ars. 3 lbs., hyd. lime 3 lbs., proprietary oil sticker 1 pt., sulfur 4 lbs., 1st cover. Lead arsenate 1.5 lbs., basic zinc ars. 1.5 lbs., hyd. lime 3 lbs., copper sulfate 3/4 lbs., 2nd cover. Basic zinc ars. 2 lbs., hyd. lime 4 lbs., copper sulfate 3/4 lb., 3rd cover. Processed nicotine bentonite 8 lbs., 4th cover. Processed nicotine bentonite 4 lbs., summer oil 3 qts., 1st 2nd-brood cover. Nicotine sulfate 1 pt., summer oil 3 qts., 2nd 2nd-brood cover.	3058	9.6	12.4	84.5	0.013	0.019
13	Lead ars. 3 lb., hyd. lime 3 lbs. proprietary oil sticker 1 pt., sulfur 4 lbs., 1st cover. Lead ars. 1.5 lbs., basic zinc ars. 1.5 lbs., hyd. lime 3 lbs., copper sulfate 3/4 lb., 2nd cover. Basic zinc ars. 2 lbs. hyd. lime 4 lbs., copper sulfate 3/4 lb., 3rd cover	2566	15.9	16.2	79.2	.017	.023
14	Processed nicotine bentonite 8 lbs., sulfur 4 lbs., 1st cover. Processed nicotine bentonite 8 lbs., 2nd and 3rd covers, and 1st and 2nd 2nd-brood covers	2950	14.1	10.8	81.5	--	--

*/ Plots 1-10 had the following spray schedule during 1st brood. 1st cover lead ars. 3 lbs., hyd. lime 3 lbs., sulfur 4 lbs., skim milk 1/4 lb. 2nd and 3rd covers, calcium ars. 3 lbs., hyd. lime 6 lbs., copper sulfate 3/4 lb.

**/ Analyses by G. W. Pearce and A. W. Avens of the New York Agricultural Experiment Station.

Table 2. Results of Experiments with Insecticides for Codling Moth Control
Poughkeepsie, N.Y. - 1939 Var. Cortland

Plot No.	Materials Applied in Cover Sprays* (Quantities per 100 Gallons)	Apples per Tree	Injuries per 100 Apples: Worm Holes	Injuries per 100 Apples: Stings	Apples Clean Percent
17.**	Nicotine sulfate 400 cc., Reinecke salt 300 grams, proprietary oil sticker 1 pt. 2 covers 2nd brood	3740	18.8	14.4	78.5
18.	Processed nicotine bentonite 4 lbs., summer oil 3 qts., 2 covers 2nd brood	3591	15.8	14.1	81.0

*/ During 1st brood the following spray schedule was used. 1st cover lead ars. 3 lbs., hyd. lime 3 lbs., sulfur 4 lbs., skim milk 1/4 lb. 2nd and 3rd covers calcium ars. 3 lbs., hyd. lime 6 lbs., copper sulfate 3/4 lb.

**/ This formula was developed and suggested by Roy Hansberry and L. B. Norton of Cornell University and the New York Agricultural Experiment Station.

Table 3. The effect of Sugar on Stomach Poisons for Codling Moth in Field Tests
Poughkeepsie, N.Y. - 1939. Var. Rome Beauty

Plot No.	Materials Applied in Cover Sprays (Quantities per 100 gallons)	Apples per Tree	Injuries per 100 Apples: Worm Holes	Injuries per 100 Apples: Stings	Apples Clean Percent
15.	Lead ars. 3 lbs., hyd. lime 3 lbs., sulfur 4 lbs., skim milk 1/4 lb. 1st cover. Lead ars. 3 lbs., hyd. lime 3 lbs., copper sulfate 3/4 lb. 2nd cover. Calcium ars. 3 lbs., hyd. lime 6 lbs., copper sulfate 3/4 lb. 3rd cover. Xanthone 2 lbs., hyd. lime 3/4 lb., tar soap 1 lb., 1 cover 2nd brood	2561	4.6	19.4	83.8
16.	Same as for 15 except that 12 lb. of No. 13 brown sugar was included in each cover	2767	6.3	25.6	80.5

Plots 1 to 10 had the standard schedule of one cover of lead arsenate followed by two covers of calcium arsenate applied to them during first brood. This was followed in most instances by a nicotine schedule during second brood. While such a first brood schedule may not be as effective against codling moth as a straight lead arsenate or fixed nicotine program it does offer protection against apple maggot and usually has residues within the tolerances at harvest. As will be noted from table 1 arsenical residues on Cortland apples were slightly above the tolerance with this program during 1939. This was partially due to heavy spraying, and the dry season. Plot 12 consisting of one cover of lead arsenate, one cover of lead arsenate and zinc arsenate combined, and one cover of zinc arsenate at a light dosage followed by a fixed nicotine and oil schedule maintained better control than the other schedules and offered protection against apple maggot. However, the arsenical residue was slightly above tolerance. Plot 11 which consisted of a tank-mixed nicotine bentonite used throughout the season gave better control than the other programs except plot 12. However, the visible residue was very heavy and it was necessary to wash the fruit with a sodium silicate solution before it could be marketed, and no protection was present for apple maggot. Processed nicotine bentonite (plot 5) with summer oil appeared to be more effective than the processed nicotine bentonite alone (plot 2). Xanthone (plot 6) reduced codling moth injury and seemed worthy of further testing. Summer oil alone (plot 8) and a proprietary material (plot 7) containing derris resins, pine oil, and ethanolamine soap were not very effective against the codling moth as used. One half pint of nicotine sulfate per 100 gallons of spray gave as good control as one pint of nicotine when used with summer oil. Sugar when added to a stomach poison did not increase the control of the codling moth. (table 3).

Tests at Kinderhook:-

A three acre plot consisting of McIntosh and Rome Beauty apples was used for this test. The spray program used was the same as that used in plot 12 of the Poughkeepsie tests. Dates of application were first cover June 8, second cover June 17, third cover June 30, fourth cover July 11, fifth cover (first second brood) August 1, and sixth cover August 10. The calyx and curculio sprays were applied by the grower.

While control was not considered entirely satisfactory, this orchard which had more than 80 percent injury in 1938 had the infestation reduced to 28 percent on McIntosh apples. Worm holes averaged 22.6 and stings 17.7 per 100 apples on the McIntosh apples. The grower using two covers of lead arsenate followed by four covers of processed nicotine and summer oil, which was a more costly program and one that had less protection for apple maggot, had 27.3 worm holes and 13.5 stings per 100 apples. The Rome Beauty plot averaged 25.3 worm holes and 8.7 stings per 100 apples. Residues of both lead and arsenic were within the tolerances.

Band Experiments

The large scale band experiment was continued for a second year. The area banded was increased in size so that it consisted of approximately 17.25 acres, and was 23 rows wide by 25 rows long. The 467 trees in this area were scraped thoroughly before codling moths began emerging. Infestation records on a similar block of trees adjacent to this area, but unbanded, were used as a comparison. The growers practices including spraying were the same in both blocks. Infestation records were taken on McIntosh, Duchess and Greening varieties. Chemical bands containing beta-naphthol oil were placed on all trees in the banded area that were old enough to have rough bark. Other trees such as the Greenings were banded with burlap-paper bands and examined at ten-day intervals.

The number of larvae captured per tree in the bands for 1939 averaged 20 for large McIntosh, 10 for average size McIntosh, 7 for Duchess, 4 for young Greenings, and 6 for young Cortlands. The number of larvae removed from the 467 trees banded was 3324. This number appeared small when compared to the number of worm holes present, which indicates that the thorough scraping of the trees probably influenced the amount of injury more than the banding.

In the banded area approximately 84 percent of the fruit (based on an unweighted average of all varieties) was clean, as compared to 67 percent of the fruit in the non-banded area. Differences in the infestation between the two areas were greater at the end of the second year than it was at the end of the first year, indicating an accumulative effect. Table 4 shows the infestation in the two areas by varieties for 1939.

The cost of scraping and banding based on labor at 28 cents an hour was approximatly 20 cents for each mature tree and 9 cents for each young tree. The latter figure includes the examination of the bands at ten-day intervals. This cost was offset at the end of the season by an additional 3.41 bushels of clean apples for each McIntosh tree, 2.19 bushels for each Duchess, and 0.85 bushels for each Greening tree that was scraped and banded.

Table 4. Results of Large Scale Band Experiment, Kinderhook, N.Y. - 1939

Variety	Apples per Tree		Worm Holes per 100 Apples		Stings per 100 Apples		Percent of Apples Clean		Injuries per Tree	
	Banded	Unbanded	Banded	Unbanded	Banded	Unbanded	Banded	Unbanded	Banded	Unbanded
Duchess	3738	2977	5.9	15.3	9.0	19.6	90.3	81.5	516	907
McIntosh (large trees)	4089	4942	15.7	42.6	9.5	21.0	83.4	64.8	1024	3140
McIntosh (ave.trees)	2206	2108	13.9	41.8	5.8	17.0	86.6	64.6	439	1259
McIntosh (ave. trees)	1695	1985	14.2	34.0	6.8	18.9	86.1	69.2	355	1045
Greening (young trees)	611	418	19.5	52.4	13.2	36.5	76.9	56.0	192	338
All Varieties Ave.	2597	2596	13.8	37.1	9.5	23.8	84.3	67.3	532	1389

Bait Trap Experiments

A comparison of six different bait solutions in a Latin-square arrangement, indicated that bromstyrol (1/2 cc. per quart) in a ten percent brown sugar solution was more attractive to codling moths during a hot dry season, such as 1939, than the oil of sassafras (1/2 cc. per quart) in ten percent brown sugar solution was. Previously the oil of sassafras bait had been considered the most effective bait for this locality. The bromstyrol bait averaged approximately 46 moths per trap during the season as compared to approximately 21 moths per trap for the oil of sassafras bait. Anethol (1/2 cc. per quart) in ten percent brown sugar solution also appeared to be superior to the oil of sassafras-sugar bait averaging 38 moths per trap.

A 7.25 acre block of McIntosh trees with a bait trap operated in each tree had 79.88 percent clean fruit at harvest, as compared to 82.2 and 76.4 percent clean fruit in two similar areas, but unbaited, adjacent to it. The part of the orchard used as the check area was baited during 1937-38 whereas the 1939 bait area was used as the check area. In 1938 the check area (1939 bait area) had 83.5 percent clean fruit at harvest as compared to 89.9 percent clean fruit for the bait area (1939 check area). Thus we find that in 1939 the percent of clean fruit in the baited area was reduced only 3.6 percent below that of the previous year; as compared to a reduction of 7.7 percent in the unbaited area. A total of 8764 codling moths were captured during the season of 1939 in the 217 traps located in the baited area. This was an average of 40 moths for each trap. The oil of sassafras and brown sugar bait was used through spring brood activity. This was alternated by rows with the bromstyrol and brown sugar bait during first brood activity.

Fumigation of Prop Poles for Killing Hibernating Codling Moth

Fumigation experiments were conducted on 2 piles of poles stacked in "wigwam" fashion. Approximately 1000 poles cut from young trees, many still containing rough bark, were in each pile. Stacks were about 10 feet wide at the base, 20 feet high and contained about 1000 feet of space. Heavy truck tarpaulins were placed over the poles and held in place by ropes for retaining the fumigant. Five cheesecloth bags containing codling moth pupae were placed in each stack at various distances from the ground for the purpose of checking results more readily. Hydrocyanic acid gas was used as the fumigant. In one stack gas was generated by placing 1 pound of sodium cyanide eggs in sulfuric acid in 2 battery jars on opposite sides of the base. In the other stack 2 pounds of calcium cyanide was placed on the ground under the poles. The fumigants were released about 4 P.M. on a still day and the tarpaulins left in place until 8 A.M. the following day. Where sodium cyanide was used the kill was 100 percent, whereas 42 percent survived where calcium cyanide was used.

Apple Maggot Investigations (O. H. Hammer)

Observations and experiences in previous years have led to the opinion that the combination of weather conditions that occurred in 1939 in the Hudson Valley, characterized by subnormal precipitation and above normal mean temperatures, is unfavorable for optimum development of the apple maggot. While the 1939 observations indicate that this year was no exception, still the pest was abundant enough to cause appreciable damage in many poorly and untimely sprayed plantings.

Fly emergence records obtained by daily examination of trap cages placed over infested soil show that adults began to emerge on June 19 in the vicinity of Poughkeepsie, N.Y. The peak of emergence occurred on July 10 and emergence ceased on August 16. Both of these two phases in the life history of the apple maggot came a few days earlier in 1939 than during what is considered a normal year based on annual records for the past ten years. It is quite probable that the peak emergence on July 10 was not a true peak but emergence was limited due to lack of soil moisture. It is probable also that emergence would have continued later than August 16 if the soil had been sufficiently moist to permit the flies to penetrate it.

Control Experiments

Apple maggot control tests in the Hudson Valley in 1939 were designed first to determine the efficiencies of various insecticides against this pest; second to determine their place, if any, in the codling moth control program; and third to avoid a spray residue problem in controlling both species. In 1939 control experiments were conducted in five small plantings each containing 25 to 100 apple trees. The experimental spray and dust applications were all timed especially to give maximum protection against the maggot. Results of the '1939 orchard-control-tests' are presented in table 5.

As a fumigant against the soil-infesting stages of the apple maggot, dichloroethyl ether, diluted 1 ounce and 1/2 ounce in 1 gallon of water and used at the rate of 1 gallon per square yard of soil area, was ineffective.

Table 5. Results of Experiments in Apple Maggot Control, Hudson Valley, N.Y.,1939

Orchard Number	Dates of Treatments and Materials Used. For Dust-parts per 100. For Sprays* Amounts per 100 Gallons	Variety of Fruit Examined	Percent Infested 1939	Percent Infested 1938
1	June 26, July 6, July 17, July 27	Red Astrachan	90.1	no crop
	Dust:- phenothiazine 15 parts,	McIntosh	21.6	30.0 estimated**
	walnut shell flour 25 parts,	Fameuse	89.1	66.2 record
	dusting sulfur 60 parts			
2	June 26:- phenothiazine 1-1/2 lbs.	Yellow Trans.	46.3	75.0 estimated
	soybean flour 1/2 lb.	Jonathan	66.8	90.0 estimated
	July 10 & July 25:- same as above	Jonathan	68.7	90.0 estimated
	except only 1 lb. phenothiazine			
3	June 26, July 10, July 26:-	Red Astrachan	12.9	80.0 estimated
	xanthone 2 lbs., lime 3/4 lb.,	Red Astrachan	36.6	85.0 estimated
	pine tar soap 1 lb.	Red Astrachan	11.3	80.0 estimated
		McIntosh	70.5	95.0 estimated
		McIntosh	55.7	70.0 estimated
4	June 26:- Basic zinc arsenate	McIntosh	5.5	60.0 estimated
	3 lbs., lime 3 lbs., skimmilk	McIntosh	6.1	60.0 estimated
	pwd. 1/4 lb.	McIntosh	7.6	49.9 record
	July 11:- phenothiazine 3 lbs.,	McIntosh	2.4	55.0 estimated
	soybean flour 1/2 lb.; July 26:-	McIntosh	17.8	78.2 record
	phenothiazine 2 lbs., soybean			
	flour 1/2 lb.			
5***	June 26:- Basic copper arsenate			Grower reported
	3 lbs., lime 4 lbs., commercial	Cortland	8.4	complete loss
	spreader 1 pt.	Cortland	4.1	of crop from
	July 11:-Copper arsenate 3 lbs.,	Cortland	8.7	apple maggot
	lime 4 lbs., skimmilk pwd. 1/4 lb.	Cortland	7.0	infestation
	July 25:- Copper arsenate 2 lbs.,	Cortland	7.3	
	lime 4 lbs., skimmilk pwd. 1/4 lb.			

*/
All spray materials are listed except sulfur which was used at the rate of 4 pounds of micronized material in 100 gallons of water in all of the sprays.

**/
The estimated percent infested was arrived at by casual examination of the fruit at harvest in 1938.

***/
The fruit in this orchard at harvest time bore an arsenic residue of 0.023 grains per pound.

YAKIMA, WASHINGTON

E. J. Newcomer, In Charge

Seasonal Conditions

The winter of 1938-39 was again mild, the minimum temperature at the Weather Bureau at Yakima being 13°F., Winter mortality of the codling moth was thus very low. Temperatures during the summer months, with the exception of August, were somewhat lower than in 1938, and were only a little above the normal. In August the temperature averaged 4° above August 1938, and nearly 5° above normal. There were 21 days in August 1939 with maximum temperatures of 90° or higher, as compared with only 9 in August, 1938. The rainfall was less than usual, totalling only 0.42 inch for June to September, inclusive, as compared with 1.09 inches for 1938 and a normal of 1.59 inches.

The activity of the codling moth was greater than usual, and more moths were caught in baits than in any previous season. For example, in one orchard about 17,000 moths were caught in five baits in 1938; in 1939, although the crop was extremely light, 24,000 moths were caught in the same five baits. In another orchard, over 44,000 moths were caught in five baits in 1939.

Emergence of moths started late in April, 1939, reached a peak just before the middle of May, and continued throughout the rest of May and June. The peak of egg deposition was not reached until June 28. First-brood moths appeared July 7, with a peak emergence late in July, and moths continued to enter baits in considerable numbers until September 26. The season was thus a long one, and worm infestation was heavy.

Orchard Spraying Experiments

The chief spraying experiments with insecticides were made in three orchards in 1939, using the customary set-up of three-tree plats replicated four times in each orchard. The orchards used were: (A) Delicious, having a light infestation; (B) Rome, having a heavy infestation; and (C) Winesap, having also a rather heavy infestation. The crop was heavy in orchard B, and medium in the other two orchards.

Eight cover sprays were applied in orchard B, and six in each of the other two, applications being made as follows: Calyx, Apr. 27 - May 3; First Brood, 1st cover, May 8 - 13; 2nd cover, May 17 - 23; 3rd cover, May 26 - June 2; 4th cover, June 5 - 13; 5th cover (orchard B only), June 26 - 27; Second Brood, 5th cover (orchards A and C), July 6 - 11; 6th cover, July 17 - Aug. 1; 7th cover (orchard B only), Aug. 7; 8th cover (orchard B only), Aug. 21 - 22.

The treatments tested, and the results of the harvest counts, are given in table 1. The percentages within orchards are weighted, but the general averages of the three orchards are unweighted.

Table 1. Results of Examination of Orchard-sprayed Apples For the Control of the Codling Moth. Yakima, Washington, 1939

Plat	Treatment (Quantities are for 100 gals.)	Orchard	Wormy	Stung	Free of worms and stings
1	Lead arsenate, 3 lbs., commercial spreader 1 pt.	A	5.2	16.7	80.1
		B	15.7	38.0	55.2
		C	11.0	39.9	55.5
		Av.	10.6	31.5	63.6
7.	Processed nicotine bentonite 6 lbs. in 1st brood, 4 lbs. in 2d. Mineral oil, 3 qts. 1st brood; 2 qts. 2d.	A	6.8	2.8	91.1
		B	29.0	17.3	60.2
		C	23.2	12.6	68.5
		Av.	19.7	10.9	73.3
2	Nicotine-bentonite, U.S.D.A. schedule.[1]	A	13.0	6.7	81.8
		B	31.4	19.9	56.1
		C	22.6	19.8	63.2
		Av.	22.3	15.5	67.0
5	Nicotine-bentonite 1st and 4th sprays. Nicotine-oil as in Plat 6 in all other sprays. Nicotine, 1 pt. 1st brood, 2/3 pt. 2d brood.	A	11.5	6.9	82.9
		B	32.6	26.0	53.1
		C	26.4	21.7	60.3
		Av.	23.5	18.2	65.4
3	Nicotine-bentonite 1st 3 sprays. Nicotine-oil as in Plat 6 last 3 sprays.	A	15.3	10.8	76.9
		B	34.3	23.0	51.8
		C	36.3	23.2	52.4
		Av.	28.6	19.0	60.4
4	Same as 2 except 2/3 quantity of nicotine	A	12.7	6.8	82.5
		B	39.5	26.1	45.9
		C	35.9	19.2	54.2
		Av.	29.4	17.4	60.9
6	Nicotine, 1 pt., 1st brood 2/3 pt., 2d brood. Oil, 3 qts.	A	16.2	11.0	75.1
		B	38.0	45.5	38.2
		C	33.5	27.5	53.2
		Av.	29.2	28.0	55.5
1	Lead arsenate 3 lbs., Commercial spreader, 1 pint	A	5.2	16.7	80.1
		C	11.0	39.9	55.5
		Av.	8.1	28.3	67.8
8	Same as 1, 2d - 4th cover sprays delayed 10 days	A	3.4	10.2	87.2
		C	7.3	36.2	60.3
		Av.	5.4	23.2	73.8

[1] Nicotine-oil in last two cover sprays in orchard B; in last cover spray only in orchards A and C.

An analysis of variance indicated the following differences in percent of wormy fruit required for significance:

P Value	Orchard A	Orchard B	Orchard C
.05	4.7	7.5	9.0
.01	6.4	10.1	12.2

Thus, with the exception of Plat 7 in orchard A, all of the nicotine treatments are significantly poorer than the lead arsenate treatment (Plat 1), and for the most part plats 3, 4 and 6 are significantly poorer than plats 7, 2 and 5. The variation in time of spraying in plat 8, while resulting in uniformly cleaner fruit than plat 1, was not proved in these experiments to be significantly better.

In addition to these tests, a Jonathan orchard was used for two additional tests of nicotine as shown in table 2.

Table 2. Results of Examination of Orchard-sprayed Jonathan Apples for Control of Codling Moth. Yakima, Washington 1939.

Plat	Treatment (Quantities are for 100 gals.)	Wormy	Stung	Free of worms and stings
1	Lead arsenate, 3 lbs., Commercial spreader, 1 pt.	38.2	31.3	44.0
9	Nicotine sulfate, 1 pt., bentonite, 5 lbs., mineral oil, 1 qt., sodium lauryl sulfate 3 oz., 1st brood. Nicotine sulfate, 2/3 pt., mineral oil, 3 qts., 2nd brood.	39.7	9.6	55.1
10	Nicotine peat, 4 lbs., wood pulp, 8 lbs., wetting agents (Ammonium caseinate, 1/3 pt. 2 sprays; glue, 1 lb., 1 spray; commercial spreader, 1 pt., 2 sprays). Nicotine sulfate, 2/3 pt., mineral oil, 3 qts., last spray	54.2	16.3	38.2

The analysis of variance was not figured for these tests, but it appears that results with the nicotine, bentonite and mineral oil combination were as good as with lead arsenate, but that the nicotine peat with wood pulp was inferior to lead arsenate.

Spray Deposits: Analyses made by the Division of Insecticide Investigations showed a somewhat heavier average deposit of lead arsenate in Plat 1 than in the same plat in 1938. This may in part account for the relatively poorer showing of nicotine in 1939 as compared with previous years.

Injury: The only injury noted occurred in the Rome orchard in plats 5, 6 and 7 in which mineral oil emulsion was being used in the early cover sprays. In these plats there was a rather heavy drop of fruit following the usual June drop. The drop was heaviest in plats 6 and 7 and therefore a record was kept, from six trees in each of these plats, of the number of apples subsequently thinned from the trees and of the crop at harvest. This record, which is given below, indicates that a considerable drop must have occurred in plats 6 and 7, and that it was heaviest in Plat 6:

	Average No. apples per tree		
	Thinned	Harvest	Total
Plat 1	2,737	1,661	4,398
6	1,078	1,329	2,407
7	2,058	1,475	3,533

Size of fruit: The average number of apples per box occurring in the various plats is given below:

Plat	Treatment	Size (Av. No. Apples per Box)		
		Delicious	Winesap	Rome
1	Lead arsenate	89	116	73
2	Nicotine-bentonite (U.S.D.A.) oil emulsion in last spray only.1/	86	106	79
3	Do., oil in 2nd brood sprays	84	115	73
4	Do., reduced strength	91	110	77
5	Nicotine-bentonite; oil emulsion in 2, 3, 5 and 6.2/	95	115	76
6	Nicotine-oil	87	124	77
7	Processed nicotine-bentonite and oil	93	108	73
8	Lead arsenate	90	112	--
Av.	All Plats (except 8)	89.3	113.4	75.4

1/ Last two on Romes. 2/ In 2, 3, 6, 7 and 8 on Romes.

There is no evidence here of any effect of any of the sprays on size, except possibly in the Winesaps, where the use of mineral oil emulsion in all sprays in plat 6 seems to have reduced the size of the fruit somewhat.

Color of fruit: The comparative degree of color in some of the plats was determined. It was evident, however, that the use of nicotine-bentonite, with only one application of mineral oil had no significant effect on color, either way, and that as the number of oil sprays applied increased, the percentage of color decreased somewhat.

Residue removal: Winesap apples from plats 2 (nicotine-bentonite, U.S.D.A. schedule), 5 (same alternated with nicotine-oil), and 7 (Processed nicotine-bentonite and oil) were run through a cleaning treatment by A.L. Ryall, Bureau of Plant Industry, and later examined. Sodium silicate, 70 lbs. to 100 gals., at 115°F. for 15 seconds, followed by 1.5% hydrochloric acid at 70°F. was used in a machine containing some brushes. It is not thought that the cold acid had any beneficial effect. This treatment satisfactorily cleaned the fruit from plat 5, did a fair job of cleaning the fruit from plat 7, but failed to clean satisfactorily the fruit from plat 2. The latter, of course, had the heaviest residue of bentonite, and after cleaning, much of this bentonite was still visible on this fruit. After remaining in cold storage for a month the development of wax on these apples was so great that the residue even on the unwashed checks was more or less obscured.

Bait Trap Experiments

Results of Tests with Attractive Chemicals.

Tests were made with the following chemicals: benzyl alcohol, iso butyraldehyde, acetic acid, formaldehyde, benzaldehyde, n-butyric acid, phenyl propionaldehyde, n-propyl alcohol and normal amyl alcohol. The materials were used at various dilutions in water containing 2% saponin, and the saponin was also used alone as a check. With the exception of the acetic acid the materials gave negative results. Baits containing 2 cc. of acetic acid to 1 quart of the 2% saponin solution caught 314 moths as compared with 328 moths caught under similar conditions in a 10% molasses bait. Therefore the tests with acetic acid were repeated on a larger scale from August 11 to 24 and it was determined that a mixture of 2 cc. of acetic acid in 1 quart of 2% saponin solution caught more moths than a larger or smaller quantity of acetic acid. This dilution caught 1709 moths in 10 baits as compared with 2352 moths caught in 10 molasses baits. These results are interesting in view of the fact that no one chemical of the many others tested has shown this degree of attraction. The saponin lowers the surface tension of the water sufficiently to wet the moths easily, and improves the method of making tests, without in itself attracting an appreciable number of moths.

Results of Tests with Poisoned Bait.

A small bag made of towelling was saturated with a solution of 50 grams of sugar and 10 grams of sodium arsenate in 100 cc. of water. The bag was placed over a wire frame in a battery jar and put in a box having an electric light that would shine up inside of the bag. Codling moths were placed on the bag and allowed to feed, the light preventing them from trying to escape. They were then transferred to other cages and the length of life compared with moths that had not fed on a poisoned bait. About 130 moths were used in the feeding test and a similar number in the check.

Two-thirds of the poisoned moths died in 1 day, and three fourths in 2 days, although these proportions of the check moths were dead only at the end of 5 and 6 days, respectively.

Biological Studies

Certain biological studies have been made in the orchards to determine the reliability of baits as indicators of moth emergence and egg laying.

Moth Emergence Records.

Moths began emerging April 22 and emergence reached a peak during the period May 10 to 14. Emergence was about completed from cages and bands in the orchards by the end of May, but there were still many to emerge from the ground and from cool places about the trunks. At the end of May many larvae and pupae were found and only 16% of these were pupae. This does not mean that 84% pupated after the end of May, as later observations showed that many of these larvae failed to pupate at all, and apparently many of them died without pupating, as the number of living larvae decreased at each observation.

Bait Records.

Moths first appeared in baits April 26, and reached a peak May 8 to 16, during a period of warm weather, when an average of 910 moths per night were caught in 5 baits. With cooler weather following and fewer moths emerging, the numbers caught in the baits were lessened and they did not again reach a high point until first-brood moths began coming in numbers late in July. At times, during cool spells, the numbers dropped almost to zero, and the average number caught daily from May 17 to June 30 was only 160, less than 1/5 the average during the peak period.

Number of Moths in Orchard.

By carefully covering trees in an unsprayed orchard with fumigating tents at intervals and volatilizing nicotine under the tents, the moths in the trees would drop to a sheet spread on the ground, and some idea of the relative numbers present in the orchard could be had. The number of moths so obtained from 8 trees fumigated once a week was as follows:

May 8	90	June 12	67
16	137	20	84
23	86	27	59
31	108	July 5	60
June 6	56	13	17

The date when the largest number of moths was found corresponds to the maximum emergence and the period of maximum entrance into baits. It should be noted, however, that relatively large numbers of moths were present until July 5, and that the average number caught after the peak period, that is, in June, was over half that at the peak, while the numbers caught in baits were less than 1/5 the numbers caught at the peak, showing that the moth population is not accurately indicated by the baits.

Egg Deposition Records.

The first eggs were observed on April 29, and eggs deposited early in May hatched in 10 days. The peak of egg deposition was not reached until June 28, although, as shown above, the greatest number of moths was present in the orchards in May. It is thus evident that more eggs are deposited per moth in late June than in May.

Hatching of Eggs.

The first eggs hatched about May 10. Data on the hatching of eggs was secured thereafter by making careful examinations every three or four days of 715 marked apples on an unsprayed tree in a sprayed orchard. The total number of worms found to have entered these apples prior to each examination is shown below:

Date	No. worms	Date	No. worms	Date	No. worms
May 16	2	June 6	115	June 25	433
19	5	9	132	28	498
23	24	12	168	July 1	544
26	44	15	243	5	580
29	49	19	283	8	630
June 3	83	22	320	12	846
				15	907

Thus, the number of worms entering these apples by periods of about two weeks was as follows:

May 15 - 31	55
June 1 - 15	188
June 15 - 30	295
July 1 - 15	369

All of these observations show (1) that the number of moths caught in the baits during the early part of the season is not an accurate indication of the number of eggs deposited, (2) that most of the eggs are deposited after the peak of moth catch in the baits has occurred, and (3) that large numbers of eggs must be deposited at times when comparatively few moths are entering the baits. Acting on this information (similar records had been obtained in 1937 and 1938), a variation in the spray schedule was tried (see Plat 8, table 1) in which the second, third and fourth cover sprays were delayed about 10 days. No significant improvement in control was shown, but the results were no worse and may have been better.

Records of Second-Brood Activity.

The earliest moths of the first brood appeared on July 7 and the peak of emergence occurred from July 23 to July 27. Second-brood larvae were entering the fruit in maximum numbers about August 8. The records indicate that the first moths of the second brood emerged about August 4 with a peak about August 20, and that the third brood of larvae was rather large this year.

Orchard Sanitation Experiments

Experiments on banding and orchard sanitation were continued in the Gilbert orchard for the 5th season, and in the Bounds orchard for the 2nd season. A new set-up in the Buchanan orchard was operated for the first time. In each case the set-up consisted of approximately 10 acres of scraped and banded trees and an adjoining 10-acre check plot, both plots being sprayed alike (except in one case discussed later). In the Gilbert orchard (Table 3) although the general level of infestation was higher than in 1938, the sanitation plot showed a definite decrease in codling moth infestation compared with the check. In this case the increased control was in spite of one less cover spray (the third) in the sanitation plot. The Jonathans in the check had 14.4 percent more fruit while the check Winesaps had 6.8 percent less.

The Bounds orchard, which was cleaner than in 1938, showed a very definite control for the sanitation program over the check in spite of a higher yield of fruit in the check for three varieties out of four.

The Buchanan sanitation plot, for which there is no yield comparison with last year, also showed a decided control compared with the check, although three of the four varieties showed a higher yield in the check plot.

Summarizing five seasons' tests, every one of the 34 comparisons, by varieties, shows a definite control value for the sanitation program.

Average Worm Capture in Bands.

In all three orchards, bands on Jonathan trees captured the highest average number of larvae per tree; from 4.7 to 5.7 times as many as Winesaps, the cleanest crop. All Jonathans averaged 149 larvae per tree, and all Winesaps, 28.

Table 3 -- Results of Sanitation and Banding Experiments, Yakima, Washington, 1939

Orchard	Variety	Percent of apples wormy		Percent of apples stung		Percent of apples clean	
		Sanitation Plot	Check Plot	Sanitation Plot	Check Plot	Sanitation Plot	Check Plot
Gilbert	Jonathan	18.3	17.5	30.7	45.8	58.4	49.1
	Winesap	3.4	4.6	28.6	32.7	70.0	65.7
Bounds	Jonathan	11.4	20.1	28.8	47.8	65.6	46.7
	Winesap	2.2	5.1	22.2	37.8	76.9	61.1
	Delicious	13.2	17.5	38.4	55.9	55.3	38.9
	Ark. Black	8.5	13.1	33.4	56.0	64.1	40.9
Buchanan	Jonathan	18.1	35.2	48.0	70.4	46.1	22.4
	Winesap	1.7	4.9	23.1	34.1	76.4	64.9
	Delicious	11.5	15.6	44.9	59.9	51.2	37.1
	Rome Beauty	11.2	27.5	38.2	69.1	57.2	27.0

Percent of Exited Larvae Caught in Bands.

In tests to determine the percent of exited larvae caught in bands on trunks or trunks and limbs of scraped trees, out of a total of 4,405 larvae that had left the fruit on 32 trees, 1,958 larvae were captured in bands, or 44.4 percent. (Last year 45.0 percent). Of these the trunk bands caught 35.9 percent and the trunk and limb bands 52.5 percent. The highest percentage caught was on Jonathans in the Buchanan orchard, 71.0 percent, and the lowest on Delicious in the same orchard, 28.0 percent Bands on Jonathans catch a larger proportion of the larvae leaving the fruit than they do on other varieties, partly due to the thoroughness with which this variety can be readily scraped.

Comparison of Bands on Trunks, Limbs and Both.

Tests as to the relative value of bands on trunks with bands on limbs and both, were continued, employing the equiponderant method, wherein the bands were alternated between the three arrangements weekly. This test was made on 18 Jonathan trees in the sprayed Stevenson orchard, 15 Jonathans, 6 Winesaps, 6 Delicious, and 6 Romes in the unsprayed Breeding orchard. The bands were shifted every 7 days, from June 23 to September 9, a total of 12 times. Of the 106,007 larvae caught, 26.3 percent were caught in bands on trunks, 34.2 percent in limb bands, and 39.5 percent in the combination of trunk and limb bands.

Of 17,692 larvae caught on 354 trees banded with both trunk and limb bands throughout the season, without changing, 4,449, or 25.1 percent were in the trunk bands, and 13,243, or 74.9 percent were in the limb bands.

Location of Hibernating Larvae.

A. As to part of tree. Minute examination of every inch of surface of 24 trees scraped and banded in 1938, showed the location of hibernating larvae in the spring of 1939 as shown in Table 4A.

B. As to kind of location. These same data were reassembled as to kind of location (Table 4B).

Table 4 -- Location of hibernating larvae as to part of tree, and as to nature of location. Survey of 24 trees scraped and banded the previous season. The data for both parts of table are from the same trees.

A. Location of hibernating larvae as to part of tree		B. Location of hibernating larvae as to kind of location	
Location	Percent of total	Location	Percent of total
Trunk	15.4	Rough bark	32.3
Scaffold limbs	17.5	Pruning wounds and broken limbs	25.5
Branches	40.7	Crotches	9.9
Miscellaneous	11.1	Holes and crevices	5.6
Trash*	14.0	Miscellaneous	11.1
Soil*	1.5	Trash*	14.0
		Soil*	1.5

* Calculated upon the data obtained in 1/4 area of tree.

Comparison of Location of Hibernating Larvae on Unscraped Trees and Trees Scraped and Banded in 1938.

This comparison was made by minutely examining in April every inch of surface of 6 Winesap trees in a scraped and banded plot and a like number in an unscraped check plot adjoining. On scraped trees 70.8 percent of the hibernating larvae were on branches, where evidently there were more suitable hibernating quarters than elsewhere. Unscraped trees showed a more equal distribution of larvae over the whole tree. Unscraped trees held 130 larvae per tree compared with only 11.3 on scraped trees.

Tests Showing Larvae Pass Over or Through Chemically Treated Bands.

Three badly infested trees banded with beta-naphthol-oil-treated bands, one series between an upper and a lower series on the same scaffold limbs, showed that 76 percent of the captured larvae were caught in the upper bands, 14 percent in the middle bands and 10 percent in the lower bands. Larvae in the middle series either passed over or through upper or lower bands or both.

Many Bands vs. Bands on Trunks, Limbs, or Both

A replicate of 4 trees for each arrangement where many (25) bands on trunks and limbs was compared with trunk bands, limb bands and both showed increase catch of larvae as follows: Many bands, 70 percent increase capture compared with trunk bands, 47 percent increase over limb bands and 36 percent more than for trunk and limb bands.

Codling Moth Larvae from 1938 Failing to Transform in 1939.

In an orchard that was badly infested in 1938, and which had many fruitless trees in 1939, and others with only a bushel or so of apples, thousands of overwintering larvae from 1938 had failed to pupate in the soil at the base of trees as late as July 6. It was thought that these might not transform during the season. After all pupation was over for the season (and even as late as November 10) hundreds of these 1938 larvae were still alive in their cocoons in the soil at the base of the trees. Cages were built about several tree trunks to study further the possibility of these larvae surviving the second winter and transforming to moths in 1940.

KEARNEYSVILLE, WEST VIRGINIA

Edwin Gould, In General Charge
G. H. Geissler, In Immediate Charge

These investigations were carried on jointly by the Bureau of Entomology and Plant Quarantine and the West Virginia Agricultural Experiment Station.

1. Seasonal Conditions and Codling Moth Abundance During the 1939 Season.

In the Shenandoah--Cumberland fruit belt abnormal seasonal conditions were in evidence during the greater part of 1939. Bloom on apples was moderately heavy, but cold wet weather during the blooming period together with heavy frosts resulted in less than one-half of a normal crop. This fact coupled with early maturing and a poor market found the majority of growers completing harvest operations at least two weeks earlier than normal.

Cold wet weather during early May delayed the peak of codling moth activity, but a period of hot dry weather from May 15 - 25 accelerated development and resulted in a moderately heavy infestation. Wet weather during the greater part of June very likely accounts for the better than usual success of first brood control of worms by means of spraying. The total rainfall during May was only .96 inches. This was the second lightest May rainfall in the past 20 years. The opposite was true during June with a total rainfall of 8.46 inches. The peak of bait pail activity was arrested on May 12 by cold weather. Activity was resumed as soon as higher temperatures prevailed and the highest first brood activity was reached on May 24 when an average of 21 moths per pail were captured. It is interesting to note that the bulk of entry occurred not from the peak of activity on May 24 but rather from the smaller and earlier peak of May 12. The peak of activity occurring May 24 failed to produce a proportionate number of entries, due to the large amount of rainfall immediately following. During the favorable conditions for flight and oviposition during the period May 15 - 25 hatching from emergence earlier in the season was taking place.

Long dry periods of weather from July 1 to September 30 resulted in considerable egg laying and hatch. This should account for a carryover of worms equal to or greater than that found in previous light crop years.

2. Field Experiments with Insecticides.

The spray testing experiments for 1939 were designed mainly toward eliminating first brood. Fifteen treatments were included in the group. Three of these treatments were applied on a large scale in blocks 12 trees long and 6 trees wide and were in the nature of a cleanup program. All spraying was discontinued after 1st brood except treatment No. 4 which was given one second brood spray. Ten of these 15 treatments were applied in duplicate orchards using the single tree plot system, with 5 one-tree replicates in each orchard. Two of the treatments (Nos. 11 and 12) were applied in one orchard only. First brood counts were made of all treatments in addition to the usual drop and harvest counts. The following summary tables give the results of all materials under treatment.

Table 1. Results of Field Experiments with Insecticides for Codling Moth Control, Stewart Orchard, Kearneysville, W. Va., 1939.

Treat No.	Materials (Amounts per 100 gals.) 1/, 2/	Total apples	Percent sound apples: 1st brood	Percent sound apples: Total	Total injury per 100 apples: Worms	Total injury per 100 apples: Stings
1.	1st cover: L.A., Flot. Sul., Lime. 2nd,3rd & 4th covers: L.A., Bordo.	4223	62.3	23.7	156	114
2.	1st & 2nd covers: T.M.Nic-Bent.,L.A. 3rd & 4th covers: L.A., Bordo.	6218	63.2	28.2	107	132
3.	1st-4th covers: T.M.Nic.-Bent.	4980	71.7	23.7	188	47
4.	1st cover: L.A.,Flot.Sul.,Lime 2nd,3rd,&4th covers: L.A,Bordo. 5th cover (2nd brood): L.A.,Bordo.	5181	69.3	41.9	37	122
5.	1st cover: L.A.,Weak Bordo. 2nd & 3rd covers: L.A.,Bordo,Nic., Sum.Oil. 4th cover: L.A., Bordo	5580	77.0	39.3	69	102
6.	1st cover: L.A.,Weak Bordo. 2nd & 3rd covers: L.A., Bordo., Sum. Oil 4th cover:- L.A., Bordo.	4330	69.9	30.2	124	105
7.	1st cover: L.A., lime(6lbs.)Nic. 2nd,3rd &4th covers:L.A.,Bordo., Nic., Sum.Oil 5th cover:Nic.(3/4pint)Sum.Oil (3qts)	5929	84.1	45.6	45	77
8.	1st cover: L.A., Weak Bordo. 2nd cover: Nic., Sum. Oil. 3rd,4th & 5th covers: Proc. Nic.Bent., Nic.(1/2 pint) Sum.Oil.	5413	87.9	46.1	71	53
9.	1st cover: L.A.,Weak Bordo. 2nd cover: Pyr.-Derr.(1pint),Sum.Oil. 3rd,4th & 5th covers: Proc.Nic-Bent Sum. Oil, Pyr.-Derr.(1/2 pint)	5628	80.2	27.2	141	65
10.	1st cover: L.A., Flot.Sul.,Lime 2nd cover: L.A., Bordo., Nic. 3rd Cover: Calcium arsenate,3 lbs., Bordo., Nic.	4578	55.6	21.5	179	106

Table 1 (Continued)

Treat No.	Materials (Amounts per 100 gals.) 1/, 2/	Total apples	Percent sound apples 1st brood	Percent sound apples Total	Total injury per 100 apples Worms	Total injury per 100 apples Stings
11.	No Calyx 1st cover: L.A.,Flot.Sul.,Lime 2nd,3rd & 4th covers: L.A.Bordo.	5595	58.2	19.6	156	125
12.	No Calyx 1st cover: L.A.,Flot.Sul.,Lime 2nd cover: L.A. Bordo. 3rd & 4th covers: L.A.,Bordo. No. 8 Brown Sugar, 8 lbs.	4913	57.6	19.3	157	138

1/ All treatments except 11 and 12 included a calyx spray of lead arsenate, 3 lbs.; lime-sulfur, 2 gallons; lime, 6 lbs.

2/ Abbreviations used in this table include the following:

Bordo. = 2-4-100 Bordeaux Mixtures
Weak Bordo. = 1/2 -1-100 Bordeaux Mixture
Flot. Sul. = Flotation Sulfur, 5 lbs.
L.A. = Lead Arsenate, 3 lbs.
Lime = Hydrated Lime, 3 lbs.
Nic. = Nicotins Sulfate (40% nicotine) 1 pint
Pyr.-Derr.= Proprietary material containing Pyrethrum and Derris extracts.
Sum. Oil. = White or Summer Oil Emulsion, 1 gallon.
T.M.Nic.-Bent.= Tank-mixed Nicotine-Bentonite: Bentonite, 5 lbs.; Nicotine Sulfate (40% nicotine) 1 pint; Soy Bean Oil, 1 qt.; Sodium Lauryl Sulfate 1/2 oz.
Proc. Nic.-Bent. = Factory-processed Nicotine-Bentonite, 4 lbs.

Table 2. Results of Field Experiments with Insecticides for Codling Moth Control, Shryock Orchard, Kearneysville, W. Va., 1939.

Treat. No.	Materials (Amounts per 100 gals.) 1/, 2/	Total apples	Percent sound apples: 1st brood	Percent sound apples: Total	Total injury per 100 apples: Worms	Total injury per 100 apples: Stings
1.	1st cover: L.A., Flot.Sul.,Lime 2nd,3rd &4th covers: L.A.,Bordo.	14,838	77.1	59.4	23	59
2.	1st & 2nd covers: T.M. Nic.-Bent,L.A. 3rd & 4th covers: L.A.,Bordo.	14,668	76.6	61.8	15	59
3.	1st -4th covers: T.M.Nic.-Bent.	11,650	89.7	64.2	44	25
4.	1st cover: L.A.,Flot.Sul.,Lime. 2nd,3rd,&4th covers: L.A.,Bordo. 5th cover (2nd brood): L.A.Bordo.	17,557	72.9	58.3	7	65
5.	1st cover: L.A.,Weak Bordo. 2nd & 3rd covers: L.A.,Bordo.Nic., Sum. Oil. 4th cover: L.A., Bordo.	16,127	83.9	61.5	15	58
6.	1st cover: L.A.,Weak Bordo 2nd & 3rd covers: L.A.,Bordo.,Sum. Oil. 4th cover: L.A.,Bordo	13,965	85.1	68.4	12	44
7.	1st cover: L.A.,Lime (6 lbs.) Nic. 2nd,3rd & 4th covers: L.A.,Bordo., Nic.,Sum. Oil 5th cover: Nic.(3/4 pint)Sum. Oil. (3 qts.)	21,395	87.4	73.0	8	39
8.	1st cover: L.A.,Weak Bordo. 2nd cover: Nic., Sum. Oil. 3rd,4th & 5th covers: Proc. Nic.-Bent., Nic. (1/2 pint) Sum. Oil.	8,291	93.4	70.4	19	29
9.	1st cover: L.A.,Weak Bordo. 2nd cover: Pyr.-Derr.(1 pint),Sum. Oil. 3rd,4th & 5th covers: Proc. Nic.-Bent., Sum. Oil, Pyr.-Derr.(1/2 pint)	10,902	85.1	50.3	65	42
10.	1st cover: L.A., Flot.Sul.,Lime 2nd cover: L.A.,Bordo., Nic. 3rd cover: Calcium Arsenate, 3 lbs., Bordo. Nic.	17,457	62.1	53.5	42	83

1/ All treatments included a calyx spray of lead arsenate, 3 lbs.; lime-sulfur, 2 gallons; lime, 6 lbs.

2/ Abbreviations and amounts as in Footnote 2, Table 1.

In practically all cases the percentage of total infestation over that of 1st brood was greater in the more heavily infested Stewart orchard than in the Shryock. This more clearly shows the value of 1st brood counts in properly interpreting the value of a given treatment and also the value of duplicate experiments with varying moth populations.

The three cleanup blocks A, B and C are summarized in table No. 3. They were applied in large blocks without replication.

Table 3. Summary of Spray Treatments - Cleanup Program - Shryock Orchard, Kearneysville, W. Va., 1939.

Treat. No.	Materials (Amounts per 100 Gals.) 1/, 2/	Total apples	Percent sound apples		Total injury per 100 apples	
			1st brood	Total	Worms	Stings
A	1st cover: L.A.,Nic., Lime (6 lbs.) 2nd, 3rd & 4th covers: L.A., Nic., Sum. Oil. Bordo. 5th cover: Nic. (3/4 pt.),Sum.Oil.(3 qts.)	19,949	84.8	65.9	17	44
B.	1st, 2nd, & 3rd covers: T.M. Nic.-Bent. 4th cover: L.A., Nic.,Sum. Oil., Bordo. 5th cover: Nic. (3/4 pt.), Sum. Oil. (3 qts.)	17,014	83.7	54.6	35	58
C.	1st cover: L.A., Wettable Sulfur, 5 lbs. 2nd - 5th covers: L.A., Bordo.	14,306	63.5	47.2	20	89

1/ Lead arsenate, 3 lbs., lime-sulfur, 2 gal., lime 6 lbs., in calyx spray in all treatments.

2/ Abbreviations same as those in Table 1.

The nicotine-oil-lead schedule (A) gave significantly better control than the standard Bordeaux-lead schedule. Treatment A resulted in 58.2 percent less 1st-brood infestation than the standard (C) treatment. However, 2nd-brood buildup was proportionately greater and offset somewhat the superior control of the nicotine-oil-lead treatment.

Treatment B consisted of 3 covers of tank-mix nicotine bentonite supplemented by a 4th cover of Bordeaux-lead-oil-nicotine and a 5th cover of oil-nicotine. This treatment is comparable to A during 1st brood but the 2nd-brood buildup was far greater.

These results clearly indicate that a toxic residue is necessary to prevent 2nd-brood buildup. The practicability of such 1st-brood treatments lies in reducing dense populations in special cases, but cannot be considered as an annual practice.

3. Biological-Mechanical Control.

This project was begun in 1935 and was planned for the control of codling moth by a virtually non-spray program of mechanical control measures and by stimulation of parasite and predator populations.

During the 1939 season the orchard was pruned and scraped as is the annual practice. A pink spray of lime-sulfur 1-50 was applied April 15 - 19 and a petal-fall application of lime-sulfur 1-50, lime 6 pounds and lead arsenate 3 pounds per 100 gallons May 4 - 11. Prolonged periods of application were due to irregular bloom. All trees, trunks and scaffold limbs, were banded June 14 - 16 with 2-inch corrugated paper and were changed once each week until pupation had entirely ceased.

These two tables below give a complete summary of the more important results recorded during the past five years.

Biological-Mechanical Control Project
5-Year Summary of Annual Records

Year	Ave. Yield per Count Tree	% Wormy	% S.& W.	% Stung	% Parasitized	% Predatored
1935	998	48.0	22.0	7.9	--	--
1936	5070	47.7	4.7	3.0	3.5	2.3
1937	1923	37.9	22.2	11.7	6.5	10.5
1938	3408	45.0	13.7	3.8	6.6	12.6
1939	1357	34.7	19.2	7.8	4.7	13.3

Year	Total Crop in Bushels	% Crop Dropped	Percent Fruits Injured		
			Drops	Harvest	Total
1935	-	50.3	91.2	66.4	77.9
1936	6593	60.9	71.3	33.7	55.4
1937	3421	44.5	88.7	58.3	71.8
1938	5106	66.3	75.7	36.4	62.5
1939	3352	50.4	76.6	46.6	61.7

A comparison of the annual worm injury as shown in the above tables indicates that 1939 had the second lightest infestation in 5 years with a total of 61.7 percent of the fruits injured. Important is the fact that 34.7 percent of the total drop-harvest counts were wormy (lowest in 5 years) and 19.2 percent in the stung and wormy class. Only 7.8 percent of the fruits were stung.

In comparing the annual parasite catch under bands in past years, the 1939 figure of 4.7 percent is less than 1938 (6.6%) and 1937 (6.5%) but greater than 1936 (3.5%). These figures are still too low to have any but slight bearing on control.

Comparison of the annual predator catch shows 1939 higher than any previous year. A total of 13.3 percent of the larvae were destroyed under bands this season as against 2.3 percent in 1936. Since this represents only a small part of a given worm population destroyed by predators, it is obvious that these insects play a large part in reducing the population.

The summary of 1st brood and drop harvest counts is given below.

	Total Fruits	% Inj.	% Sound	% Stung	% Wormy	%Stung & Wormy	W 100	S 100
First Brood	135,764	38.0	62.0	10.9	18.6	8.5	39	25
Drop-Harvest	135,722	61.7	38.3	7.8	34.7	19.2	113	38

VINCENNES, INDIANA

L. F. Steiner, In Charge

Seasonal Conditions

Mortality of hibernating larvae during the winter of 1938-39, which approximated 25 to 30 percent, was caused largely by disease and prolonged warm fall weather. Winter temperatures were mild but the carry-over of larvae appeared less than normal apparently because the early 1938 harvest found a larger proportion of larvae still in the fruit.

Temperatures and development in 1939 were normal until September, when the hottest weather of the year prevailed, the maximum being 106°F. on September 8. Rainfall for the first six months totalled 25.79 inches with 7.34 inches in April and 5.86 in June. A serious apple scab situation developed as a result. Rainfall in July, August and September totalled 2.70, 2.04 and 1.07 inches respectively and the change to drouth conditions and higher temperatures in September caused serious defoliation and premature drop of fruit in some orchards. Approximately 40 percent of the fruit dropped before harvest in one orchard where the moisture deficiency was less acute than in most.

Spring-brood moth emergence began about May 6 and was practically complete in the orchards by June 7. Moths were abundant throughout June, however, since adults of the first brood began emerging June 23. Hatch of eggs first took place about May 20 and reached a sharp peak the first week in June. Mature larvae were leaving apples June 8, 20 days after the first hatch, as in 1938.

Bands yielded their peak catches during the 7-day period ending July 5. These catches were not again exceeded until late in August.

In general lead arsenate gave poor results during the hot dry August and September so that wherever used the third-brood attack was severe. The present hibernating brood is larger than normal throughout southwestern Indiana.

Control by Insecticides

Insecticide tests were of three types, laboratory, laboratory-field, and large scale control tests. All types were supplemented by chemical analyses of spray deposits made by the Division of Insecticide Investigations.

Laboratory Experiments

Some 53,000 newly hatched larvae were employed in winter laboratory tests of numerous variations of fixed nicotine formulae and of new insecticide materials so that some basis could be had for the final selection of treatments for field testing.

Laboratory-Field Experiments

Nearly 50 formulae and variations in schedules were tested by this method which has been described in previous reports and in multigraphed circular E-488 (Sept. 1939).

Briefly, it requires the exposure under controlled conditions of stratified samples of field sprayed fruit (80 per treatment) to a known number (usually 640) of newly hatched larvae in the laboratory. Efficiency is calculated by comparing entrances in the treated fruit with those made in untreated checks. Experiments were conducted before, after, and occasionally between the various spray applications.

The principal series of tests were conducted on Rome Beauty in a 17-year-old orchard. Plots were arranged for convenience in spraying since no harvest counts were intended. Sprays were applied with a portable outfit from a 10 ft. tower and from the ground, each cover spray being a complete inside-outside application. All parts of the trees were sprayed to the point where run-off began. This required approximately 22 gals. per tree. The spray outfit was operated at 500 lbs. pressure with disk openings in the tower gun and ground broom of a size that would permit an output of 12 to 15 gals. per minute. A total of 245,000 larvae were used in the 1939 laboratory-field tests.

Some of the more important results have been averaged and summarized in Table 1. While this method of presentation fails to show the extent of differences at critical periods during the season, it makes possible simple comparisons of the treatments.

Table 1. Average Percent Larvicidal Efficiency Before and After Cover Sprays and at Harvest. Vincennes, Indiana. 1939.

Abbreviations used. LA-lead arsenate Bentonite - Wyoming bentonite, Bdx.-3/4-1-1/2-100 bordeaux mixture, STM - standard tank mix of 1 pt. nicotine sulfate, 5 lbs. bent., 1 qt. soybean oil with nicotine sulfate and bent. reduced to 2/3 strength in 5th to 7th cover sprays.		2nd to 4th cover sprays 5/29, 6/6, 19.		5th to 7th cover sprays 7/5, 19, 8/1		
		Before	After	Before	After	Harvest 9/13
Plot	Materials per 100 gals.					
1.	LA.-Bdx. 1st cover; 4 lbs. mineral oil 2 qts.; soap 1 lb. 2nd to 4th covers using 45 gals. per tree. Not sprayed after 6/19.	70	86	90	---	72
2.	Ind.-Ill. schedule. 1st cover, same as Plot 1; 2nd and 3rd, 4 lbs. LA, 2 qts. mineral oil, Bdx.; 4th, 4 lbs. LA, Bdx.; 5th to 7th, 3 lbs. LA, Bdx.	51	66	81	87	62
3.	Fact. Proc. Nic.-bent. 6 lbs. with 2 qts. mineral oil. (1st cover 8 lbs. with 3 lbs. sulfur, 2nd cover 6 lbs. with 1 qt. soybean oil).	53	81	81	93	83
3a.	Same as 3 plus 4 ozs. copper phosphate in 2nd and 3rd covers, 6 ozs. in later sprays.	47	79	77	92	43
4.	STM with 1/2 oz./ sod. lauryl sulfate	64	87	89	94	85
5.	STM	69	90	88	96	85
5a.	STM 1st to 4th covers, 2/3 pt. Nic.-sulfate 2 qts. mineral oil, Bent. 1/2 lb., 5th to 7th covers.	69	90	85	93	75
5b.	STM 1st to 6th covers. Same as 5a in 7th	69	90	88	96	79
6.	STM plus 1/4 lb. soap, 1st to 4th covers, discontinued later.	64	87	---	---	---
7.	Same as 6 in 1st to 4th, same as 5b later except 4 ozs. copper phosphate in 2nd and 3rd covers, 6 ozs. in all later sprays.	63	85	76	90	46

Table 1. (continued)

Plot	Materials per 100 gals.	Before	After	Before	After	Harvest 9/13
8.	1 pt. nic. sulfate, 5 lbs. bent., 1/4 lb. soap, 1/2 lb. Phenothiazine, 1st to 4th covers; nicotine and bentonite reduced to 2/3 strength in later covers.	60	81	83	91	75
9.	Same as 5 except extra quart soybean oil in 2nd to 4th covers, 1/4 lb. soap substituted for soybean oil later.	69	92	91	94	88
10.	Split schedule: Same as 5 in 1st to 4th covers except herring oil substituted for soybean. 5th cover 6 lbs. LA, 2-4-100 bordeaux. 6th and 7th covers 3 lbs. LA, 2-4-100 bordeaux.	64	85	84	84	75
11.	Same as 5 except corn oil substituted for soybean oil.	66	90	90	96	85
12.	Same as 5 except heavy bodied soybean oil substituted for regular grade beginning with 4th cover.	69	89	88	94	84
13.	STM with 1/4 lb. soybean flour, 1st-4th covers. (Discontinued).	67	88	--	--	---
	Average of differences required for significance 1% Odds.	7	5	7	5	7

The larvicidal efficiencies of lead arsenate treatments cannot be compared directly with those of nicotine combinations in evaluating their relative effectiveness because of other factors besides larvicidal efficiency which contribute to control. However, reliable comparisons within each class can be made. Tests which involved the placing of 500 newly hatched larvae on the foliage of 100 bearing spurs well distributed over the trees in these plots indicated that in weather highly favorable for worm activity an efficiency of 88 percent for lead arsenate as determined in the laboratory prevented the entrance of more than 99 percent of the larvae, while to obtain similar control with nicotine-bentonite an efficiency of 96 percent was required. These figures do not take into account the ovicidal and other effects of the treatments. A laboratory efficiency as low as 78 percent for the nicotine treatment gave 93 percent control. While efficiencies of 87 and 88 percent for Plots 1 and 2 (lead arsenate) in three tests permitted survival of only 0.3 to 1.2 percent of the worms they were not sufficient to prevent severe sting injury. From 24.4 to 34.4 percent of the worms stung the fruit. The nicotine-bentonite permitted only 5.8 to 6.4 percent stings. From 59.2 to 65.0 percent of the worms placed on unsprayed trees survived and from 8.0 to 10.6 percent made stings. In unfavorable weather the larvicidal efficiency does not need be so high for nearly perfect control.

It is evident from Table 1 that Plot 1, the oil-soap-lead combination which received the same total volume of spray material as Plot 2 was capable of giving nearly complete control of worms but not of stings and though all of the material was applied in the first-brood period, protection later in the season was superior to that from the recommended Indiana schedule.

Plot 10, which was given a split schedule of nicotine-bentonite-herring oil followed by lead arsenate-bordeaux, was equal or superior in efficiency to Plot 2 throughout the season. Lead residues at harvest on Plots 1, 2, and 10 as determined by Mr. Fahey were 0.205, 0.117 and 0.121 grains per lb. of fruit respectively. These residues were reduced to 0.048, 0.017, and 0.009 grs. per lb. by a washing treatment of 1.5% HCL for 30 seconds at 80°F. in an underbrush machine, illustrating again, as in the past the greater ease of removal of residues from deposits applied late in the season.

The standard tank-mix nicotine-bentonite-soybean oil combination (Plot 5) was again outstanding despite efforts to improve it. The addition of sodium lauryl sulfate (Plot 4), soap (Plot 6) or soybean flour (Plot 15) to smooth out the early deposits failed to increase the efficiency. Likewise the use of extra soybean oil (Plot 9) or the substitution for soybean oil of herring oil (Plot 10 during first-brood), corn oil (Plot 11), or heavy bodied soybean oil (Plot 12) failed to increase the efficiency. It is important to note, however, that the substitution of 1/4 lb. neutral soap for soybean oil in the last three sprays (Plot 9) did not cause any reduction in efficiency. This was also noted in 1935 tests. Use of soap early in the season is detrimental. Herring oil at times during the first-brood period caused significant reductions in efficiency. Corn oil can safely be substituted for soybean although further tests are needed. This would be of advantage only in seasons when it costs less than soybean oil.

The substitution of mineral oil-nicotine sulfate in the second-brood period for the standard tank mix treatment (Plot 5a) avoided all residue difficulties but resulted in a greater loss in efficiency through the period of third-brood attack.

One factory-processed material (Plots 3 and 3a) was included to study the effect on efficiency resulting from the addition of a small quantity of a neutral copper fungicide, the idea being to build up a small but uniform copper load as a protection against bitter rot by using lower dosages in more applications. Although the figures shown in Table 1 for Plots 3 and 3a do not appear significantly different except at harvest, the efficiencies where copper phosphate was added were consistently lower which makes the difference significant. The same was true of Plots 6 and 7 in the first brood and 5b and 7 later, copper phosphate having the same deleterious effect on efficiency of the fixed nicotines when used in small quantities as when used in the larger dosages as reported in 1938. In a test not shown in Table 1, 6 ozs. of copper phosphate per 100 gals. was added to the 7th cover spray of mineral-oil nicotine sulfate on part of Plot 5b. Without the copper phosphate the efficiency dropped from 97 percent after the spray to 88 percent 4 weeks later but with it added it dropped from 97 to 79 percent.

No injury resulted on any of the plots from the use of the small quantity of copper phosphate although analyses by Mr. Fahey showed that we had built and maintained copper deposits equal to those on Plot 2.

The substitution of 1/2 lb. phenothiazine as a fungicide and 1/4 lb. soap (Plot 8) for soybean oil in the standard tank mix (Plot 5) gave significantly lower efficiencies throughout the season although the difference was less during the second-brood period.

Growers using the tank-mix combination in a bitter rot area must, until a suitable substitute for bordeaux mixture is found, be prepared to change to a heavy bordeaux or lead-bordeaux program if the disease makes its appearance during the season. Tests in 1939 indicated that the adverse affect of bordeaux or lime applied over the nicotine deposits was less, early in September than in July. On Plot 10 for example, the nicotine load was reduced from 2.6 to 0.7 mmgs. per sq. cm. overnight after application of the first bordeaux spray July 5. On Sept. 5 bordeaux and lime sprays were applied to Ben Davis fruit carrying nicotine loads of 1.6 mmg. per square cm. After the spray the nicotine load remained unchanged and 2 days later had only dropped to 1.0 mmg. per sq. cm. This suggests that wax formation began to submerge the nicotine deposits, thus protecting them from the alkaline spray.

Maintenance of Efficiency Over Long Periods:

Fixed nicotines if thoroughly applied in the first-brood period are capable of maintaining a reasonably high efficiency for two months or longer.

Since Plot 1 received no second brood sprays parts of certain other plots were left unsprayed from June 19 to Aug. 30 when a spray of 2/3 pt. nicotine sulfate and 2/3 gal. mineral oil per 100 gals. was applied to the nicotine plots. Larvicidal efficiencies at intervals between June 19 and Sept. 8 are shown in Table 2. The plot numbers given in this table refer to the corresponding treatments in Table 1 ending with the 4th cover spray.

Table 2. Larvicidal Efficiencies at Intervals after Four First-Brood and One Third-Brood Spray Application.

Plot	Date of sample and age of newest deposits					
	6/20 1 day	7/25 36 days	8/16 58 days	8/30 72 days	8/30 after spray	9/8
1. Oil-lead-soap	90	91	91	78	--	72
2. Ind-Ill. LA. schedule	76	66	61	47	--	32
5. STM	93	78	64	54	79	77
8. TM-phenothiazine	90	59	50	34	76	59
9. STM with extra soy oil	96	76	65	43	82	63
10. TM - herring oil	88	62	56	(discont'd)		--
11. TM - corn oil	94	78	61	46	77	62
Least significant difference-1% Odds	4	7	8	9	9	8
Rainfall between dates		2.28"	2.51"	0.23"	0	0.05"

Among other things these results verify the finding as shown in Table 1 that herring oil is not a satisfactory substitute for soybean oil and also indicate that corn oil may be less satisfactory. It is significant that the application of a third-brood spray was sufficient to raise the efficiency of the standard tank-mix to the level of the best lead arsenate treatment.

Influence of Bentonite on Toxicity of Phenothiazine:

On August 21 certain phenothiazine treatments were applied to single Ben Davis trees of uniform size which had been sprayed with nicotine bentonite earlier in the season.

The object of this experiment was to test the value of a weak nicotine-bentonite mixture as an adhesive for phenothiazine and to test the value of a phenothiazine-talc dust as well as to study further the effect of bentonite on the toxicity of phenothiazine. The data are summarized in Table 3.

Table 3. Larvicidal Efficiency and Deposits from Phenothiazine-Bentonite Combinations. Vincennes, Indiana. 1939. (Deposits in mg. per sq. cm. by Insecticide Division)

		8/21	8/23	9/5	9/18 Harvest
Residual efficiency prior to phenothiazine sprays. Trees last sprayed by grower in July.	% Effic.	46.1			
Plot 20 - Phenothiazine 4 lbs.	% Effic.	93.4	90.2	76.7	52.6
	Pheno.	19.9	19.2	11.1	6.6
Plot 21 - Pheno. 4 lbs. Bent. 4 lbs.	% Effic.	91.8	77.7	64.4	52.4
	Pheno.	37.9	42.5	26.2	24.2
Plot 22 - Pheno. 4 lbs. Bent. 1 lb.	% Effic.	90.0	77.6	67.9	49.5
	Pheno.	19.7	19.2	16.9	11.8
Plot 23 - Pheno. 4 lbs. Nic. Sul. 1/2 pt. Bent. 1 lb.	% Effic.	93.0	87.9	65.0	48.4
	Pheno.	30.0	33.0	20.3	12.6
Plot 24 - Pheno.-talc, 1 to 4 dust	% Effic.	93.2	56.0	32.5	20.3
	Pheno.	3.1	2.0	1.5	1.0
Least significant difference in efficiency	1% Odds	6.0	5.5	9.8	10.7
Rainfall between sample dates			0.03"	0.05"	0.75"

Note: The liquid applications averaged about 30 gals. per tree or slightly more than 1 lb. of phenothiazine. Five pounds of the dust containing 1 lb. of phenothiazine were mixed and the duster circled the tree until the entire quantity was used. Since the wind velocity was 6 miles per hour most of the dust was carried away. The tree was slightly wet with dew.

The apples from the dusted plot were samples for analysis in paper bags and a certain amount of the deposit was probably brushed off. The deposit, however, was scarcely visible while on Plots 21 and 23 it was so heavy as to be objectionable at harvest.

The results of these tests support the original finding by this laboratory in 1935 that bentonite adversely affects the efficiency of phenothiazine and although it may be a good adhesive it acts, as do all successful adhesives so far tested, in reducing the toxicity to such an extent that the loss more than offsets the gain in deposit. If the analytical method is accurate and decomposed non-toxic material is not included in the quantities measured then the results support the evidence obtained in previous seasons that phenothiazine kills codling moth larvae largely by contact, the black decomposed surface layer acting as a protection for the larvae against the toxic material underneath. It was pointed out in 1938 that rains, by apparently removing the surface layer, immediately reduced the deposit but did not always immediately reduce efficiency. Presumably the efficiency held up because pure phenothiazine was exposed and then fell one or two days later after decomposition on the surface reduced toxicity. The very high initial toxicity of the almost invisible dust deposit (Plot 24) is further evidence that the contact effect is very important.

Had normal rainfall occurred after the application of these treatments we would have had a better comparison of the sticking qualities of the different combinations. As an initial deposit builder the heavy bentonite dosage and the weak nicotine-bentonite combination were superior. It is improbable that the nicotine in the latter formula added much to the efficiency. It appears that by reacting with the bentonite the nicotine sulfate prevented the latter from having its usual deleterious effect on efficiency for a few days at least. It is probable that the 20 percent efficiency for Plot 24 at harvest constituted the residual effect of the original nicotine deposit.

Number of Spray Applications in Relation to Efficiency:

Probably because of the wide variation in types and distribution of spray deposits on the fruit particularly early in the season; there is surprisingly little correlation between amount of deposit and efficiency at that time. Although probably the most effective means of achieving a uniform deposit is by the application of large quantities of a deposit building formula the average grower in this region obtains eventual coverage of nearly all parts of all apples through repeated spraying.

For example, on Plot 5 the nicotine deposit was 4.0 mmg. per sq. cm. on May 29, 9 days after the first cover and was the same on June 12, 6 days after the second cover yet the efficiency was 49.1 and 78.3 percent on the two dates respectively. In a commercial orchard on May 29 where two sprays of the same materials had already been applied a deposit of 3.7 mmg. gave an efficiency of 70.7 percent.

Preliminary tests have indicated, however, that the production of deposits of higher toxicity by repeated applications is not attained when the volume of material used is less than sufficient to thoroughly wet that part of the tree being sprayed. For example the part of Plot 5 which had received only four first-brood sprays retained an efficiency of 54 percent on August 30, 72 days after the last spray application. These trees required 22 gals. per spray application for thorough coverage or a total of 88 gals. A total of approximately 90 gals. per tree of the same materials was applied by the grower in six cover sprays in another part of the orchard. His deposits on August 21 only 30 days after his final spray had an efficiency of 46 percent. On July 12, a few days after the fifth application, his deposits had an efficiency of 55 percent while at the same time those on Plot 5, 23 days after the last spray had an efficiency of 78 percent. It may be concluded that repeated spraying to less than the point of run-off on all parts of the tree is likely to result in poor distribution of the spray deposits on the individual apples, the surface hardest to hit being the parts that are missed repeatedly while an excess of deposit may be built upon the surfaces easiest to wet.

Importance of the Calyx Spray:

Under field conditions in May and June actual control is often better than would be expected from the low efficiency of the treatments as determined in the laboratory. This appears due partly to less favorable weather conditions, making it impossible for as many larvae to enter unsprayed fruit, and partly the smaller size of the fruit which evidently is the factor governing the proportion which attempts entrance at the calyx. Two experiments in 1939, one on May 23, at the beginning of the first-brood attack when Transparent apples averaged about 1 inch in diameter, and the other a month later when the fruit averaged 2 inches in diameter indicated that on unsprayed trees 61.6 percent of the 56 percent which survived on May 23, entered at the calyx and only 19.2 percent of the 50.2 percent which survived on June 23 entered at that point. Five hundred newly hatched larvae were placed on the foliage of 500 bearing spurs in each experiment. About 40 percent of those which entered the side of the apples did so on the cheek facing the trunk of the tree.

Both the Indiana-Illinois spray schedules now specify a full calyx application followed a few days later by a spray of the same formula applied to the upper two-thirds of the tree. On May 4, 1939, Winesaps sprayed 3 days earlier with a single calyx application of 3 lbs. lead arsenate, 3 lbs. lime and 8 lbs. wettable sulfur carried an As_2O_3 load of 37.0 mg. per apple. Part of the plot to which a top-off spray of the same solution was also applied May 3, averaged 51.0 mg. per apple. Fifty days later this had decreased about 50 percent. Deposits in the top of the tree equalled those lower down, while with the single spray top deposits averaged about 50 percent less. Since the calyx often starts closing on early blooming fruits on a tree before all the later blossoms have opened one spray seldom can be timed to protect all the fruit. Since it may be the early bloom that sets one year and the later bloom another the protection afforded by a single calyx spray is likely, over a period of years, to be quite variable.

Large-Scale Comparison of Fixed Nicotine and Lead Arsenate:

Through the courtesy of the W.C. Reed and Son Orchard Co. we were able to compare the results from commercial use of the tank-mix nicotine bentonite soybean oil and the Indiana-Illinois lead arsenate programs for the third year.

The same 25-acre lead arsenate area as used in 1938 was again employed. This was compared with nicotine sprayed areas to the north and south and to an 11-acre block on the west which received a split-schedule consisting of the regular nicotine treatment until the 6th cover spray and thereafter the same formula as was applied to the lead arsenate area. All spray materials were furnished by the Company and applied through a stationary plant by the orchard crew.

Sprays were timed by us with the aid of emergence cages,bait traps, and weekly population counts. Infestation data were obtained from 119 trees of 5 varieties (Grimes, Jonathan, Rome Beauty, Starking and Winesap) at the end of the first brood and at harvest. Larvicidal efficiency determinations were made on several occasions using a total of 40,000 larvae. In addition, deposit analyses were made by the Division of Insecticide Investigations before and after most spray applications.

After petal fall the lead arsenate area received 7 cover sprays (3 with mineral oil) and a special top-off, and the nicotine area 8 cover sprays (last two of 1/2 pt. nicotine and 0.6 gal. mineral oil per 100 gals.) and 2 top-offs. Trees in the lead arsenate area received from 16 to 22.9 gals. per complete application for a total of 149 gals. per tree after petal fall. The trees sprayed with the nicotine mixtures received from 14.6 to 19 gals. per complete application and a total of 153 gals.

Partly because of a larger crop in the nicotine area there was no difference in total worm entrances per tree in 1938. Before the cover spray program started in 1939, 40 bait traps averaged 34 moths per tree in the nicotine area and 30 per tree in the lead arsenate area. Thereafter, possibly because the nicotine sprays killed some of the adults or reduced the attractiveness of the bait, the catches were heaviest in the lead arsenate area. The season totals averaged 309 per trap in the former and 433 in the latter areas. Weekly population counts indicated that after the middle of July moths were consistently more abundant in the lead arsenate area.

Both the efficiency tests and deposit analyses indicated that the protection was less than we consider necessary for satisfactory control. It more nearly approached the optimum in the nicotine area, however. Observations indicated that the mineral oil used in the lead arsenate area early in the season was compensating for the low larvicidal efficiency with its ovicidal effect and its kill of larvae that had already penetrated the skin. The result was that control for 4 of the 5 varieties on the basis of worms per tree was best in the lead arsenate area on June 30, however, the lighter crop made a higher percentage of the fruit wormy.

The infestation at the end of the season, though heavy in both areas, was most severe in the lead arsenate area. The averages of certain infestation data for the 5 varieties are as follows:

	Number per tree			Percent of fruit		
Area	Apples	Worms	Stings	Clean	Wormy	Stung
Lead arsenate	2,992	815	1,929	51.7	22.1	37.9
Nicotine	4,144	662	366	78.3	15.2	8.0

The heavy infestation resulted partly from failure to remove all early apples from the orchard at harvest in July and to the increasing difficulty in obtaining proper coverage of the larger trees with the stationary outfit. These two factors affected both areas alike. Efficiency of the nicotine was also reduced by the addition of a neutral copper fungicide in July.

By charting the infestation to show its density in different parts of the orchard at the end of the first brood attack and at harvest it became evident that there was a considerable shift in location of the population. Those trees which were most heavily infested June 30 were not the ones most heavily infested at harvest. The infestation at harvest was much more uniform than in late June.

The split-schedule treatment, although it yielded cleaner fruit than the lead arsenate program, was not satisfactory from the control standpoint because the rate of increase late in the season was much more rapid than with either the lead arsenate or nicotine programs. Probably because of its location it had the advantage of a lower first-brood infestation than the other nicotine and lead arsenate areas.

A third-brood spray of mineral oil alone on Winesaps equaled an oil-nicotine combination in effectiveness but nearly 50 percent more solution was applied per tree. Both gave enough extra clean fruit to pay for their cost and as a further gain they reduced the potential 1940 worm population with 209 and 160 less worm entrances per tree respectively.

Crop size differences between the lead arsenate and nicotine areas on trees used both years became still greater in 1939 than it had been in 1938. The evidence is almost conclusive that the former treatment was responsible for the reduction in crop.

Use of the nicotine program was highly profitable on all varieties when compared with the lead arsenate. The cost of materials used after petal fall including labor for extra spray applications averaged $0.47 per tree more for nicotine than lead arsenate sprays, yet, despite the low 1939 prices, the fruit on record trees was worth from $1.79 more for Starking to $5.58 more for Grimes. This was partly the result of the larger crop, however, the nicotine sprayed fruit was worth from 0.09 to 0.149 more per bushel because of its higher quality. To pay for the extra cost of the nicotine sprays it was necessary that the different variaties yield from 3.1 to 6.5 bushels fruit per tree. The average production for fall and winter apples in the 212-acre orchard was 10 bushels per tree.

No difficulties with residue removal were encountered. Fruit sprayed with nicotine-bentonite was cleaned by brushing. Fruit sprayed with lead arsenate was cleaned satisfactorily by using 1.5 percent HCL for 30 seconds at 80°F. in an underbrush machine, however, the lead load on the Jonathan variety was only reduced to 0.025 grs. per pound.

Spray injury from lead arsenate was less than normal in 1939, but some copper injury resulted from the use of bordeaux mixture in the lead arsenate area.

Fumigation of Trees with Nicotine:

Tests with a nicotine vaporizer-power duster combination indicate that there is little hope of successful open air fumigation with nicotine for codling moth control. Most of the moths become paralyzed and drop to the ground without getting a lethal dose. They generally recover from the paralysis within a few hours. For population counts the vaporizer appears as satisfactory as a nicotine-lime dust providing 80% nicotine, is vaporized and blown into the tree at the rate of 80 cc. per min. for 1-1/2 minutes. In dense trees, however, not all the moths drop to the ground. Indications are that they crawl into curled leaves, or on top of level locations from which they do not dislodge themselves when they become paralyzed. This requires further investigation.

Foliage Injury:

The tank-mix nicotine bentonite was used successfully by 6 commercial growers in this area in 1939. In two of the commercial orchards severe injury developed characterized by rapid yellowing and abscission of foliage.

All of it in one case and part of it in the other was definitely caused by the deficiency in moisture but the possibility that the tank-mix deposits can increase the rate of transpiration and accelerate leaf loss in dry weather must be investigated further. The other injury occurred in May and June in a Kentucky orchard and similar injury was observed in orchards sprayed with the tank-mix nicotine in Georgia. This injury consisted of a leaf-spotting similar to "frog-eye" but the leaf tissue between and around the spots was also burned. Injury of exactly the same type but somewhat less severe was present in two instances on trees sprayed with lead-bordeaux, and was also found on foliage sprayed only with liquid lime sulfur in one pre-bloom spray. Possible causes that require further investigation were the use of liquid lime sulfur in the sprays prior to the first cover spray, the use of lead arsenate in the calyx and a first cover spray leaving arsenical residues not buffered by safeners later on, the presence of frog-eye and apple scab, which might increase penetration of leaf tissues by the spray materials, or the hot, humid and rainy weather in June. The only condition common to all orchards where the early injury occurred was the frog-eye leaf spotting and the hot rainy weather.

Applications of all ingredients in the tank-mix formula at double strength separately and in various combinations to young Jonathan trees in July and again in August with the temperature at 95°F. and the relative humidity 50 percent both times failed to produce any injury even where the treatment consisted of 1 qt. nicotine sulfate, 10 lbs. bentonite and 1 gal. soybean oil per 100 gals. and the foliage was severely injured by scab, blight and leaf spotting.

Bait Trap Experiments

Traps were operated in four orchards to aid in timing sprays, for population studies, tests of the relative attractiveness of different solutions and as a test of their control value.

Except for one test all traps were of the double, quart-jar type. Baits were normally changed at 3-week intervals, the bait in one or the other side being replaced every 10 or 11 days. During periods when an abundance of other insects were coming to the traps, they were cleaned out at each examination. In the control area except for the 20 percent of the traps examined regularly, no traps were cleaned out between regular replacements. No water or bait solution was added between changes except in one experiment.

Tests of Handling Methods

In a test of handling methods using 40 traps, best results were obtained by completely changing the solution in alternate halves of each trap at 10-day intervals rather than filling the trap with fresh bait two or three times weekly. The average catch per trap during the season was 388 and 323 for the two methods respectively. The complete change method was superior in every month during the period of moth activity.

Relative Attractiveness of Different Baits

Comparisons of 17 bait formulae were made in 1939, each test extending the full length of the season since past experience has proven that tests of short duration are unreliable regardless of the size of the population. The reason for this is that the relative efficiency of certain baits may change considerably with a change in weather conditions.

All baits were tested in series of 4 to 6 with 8 replications of each. Each replication was rotated through a separate group of 4 to 6 trees, the moves being made twice weekly.

The seasonal results are given in Table 4. One bait solution was repeated in each series for use as a standard of comparison.

The check bait (No. 1) of bromo styrol, nicotine sulfate and brown sugar was not significantly inferior to any of the baits tested in Series D-2, D-3 and D-4. In Series D-1 Bait 2, consisting of the check bait in the first brood period and Bait 14 later, gave improved results although Bait 14 was of less value when used all season. The outstanding baits were Nos. 16 and 17 consisting of oil of sassafras, sodium arsenite and 10 percent dark brown sugar.

Control Value:

Prior to 1939, most of our control tests have been conducted in poorly cared for orchards and although substantial reductions in infestation were obtained early in the season these differences were largely nullified by later migration. Studies in 1938, suggested that heavy spray deposits, either by repelling moths or perhaps by reducing their urge to oviposit, might increase the efficiency of traps, consequently the 1939 test was set up in a well sprayed orchard.

One rectangular 30-acre section of this orchard was divided into two 19 x 23 row blocks, one of which was baited with one double-trap per tree using a 10 percent solution of dark brown sugar with 1 cc. of nicotine sulfate and 1/2 cc. bromo styrol per quart. Three other experimentsl solutions were exposed in the two rows adjacent to the unbaited area.

Table 4. Average Number Moths Captured per Trap in Experimental Baits. May to September. Vincennes, Indiana. 1939

Abbreviations: BS= bromo styrol, OS = oil of sassafras, OM = oil of mace, Nic. = Nicotine sulfate 40%, S= #13 soft sugar.

Series:=	D-1	D-2	D-3	D-4
1. - BS-1/2 cc. + 1 cc. Nic. per qt. of 10% S.	88.6	126.0	61.6	110.5
2. - #1 during 1st br. #14 2nd brood.	101.5			
3. - BS 1/2 cc. per qt. of 10% S.				87.2
4. - OS 1/2 cc. " " " " ".				107.1
5. - OM 1/2 cc. " " " " "				99.0
6. - OS 1/2 cc. + Nic. 1 cc. per qt. 10% S.			59.5	
7. - Same as 6 but changed every 2 weeks.			62.2	
8. - OM 1/2 cc. + Nic. 1 cc. per qt. of 10% S.			54.5	
9. - #4 during 1 st. br. #3 2nd brood.		138.6		
10. - OS 1 cc. per qt. of 10% S.		125.4		
11. - OS 1 cc. + 1 cc. Nic. per qt. of 10% S.		121.8		
12. - OM 1 cc. per qt. 10% S.		85.9		
13. - OM 1 cc. Nic. per qt. of 10% S.		71.0		
14. - BS 1/2 cc. per qt. of 20% S.	82.8			
15. - BS 1/2 cc. + 1 cc. Nic. per qt. 20% S.	75.8			
16. - OS 1/2 cc. + 1/2 gm. $NaAsO_2$ per qt. of 10% S.	136.1			
17. - Same as #16 except poison withheld until 3rd day after change of bait.	123.9			

Least difference required for significance.

Odds	D-1	D-2	D-3	D-4
5%	11	13	11	19
1%	15	17	15	26

Both areas were sprayed alike by the grower using the tank-mix nicotine-bentonite soybean oil. The principal varieties were Winesap and Rome Beauty.

Infestation data based on counts from 10 trees of each variety in each area are summarized in Table 5.

Table 5. Codling Moth Infestation in 15-Acre Baited and Unbaited Blocks. Vincennes, Indiana, 1939.

Area	Variety	No. apples per tree	Percent of apples			Total worms and stings per	
			Clean	Wormy	Stung	100 apples	Tree
Unbaited	Winesap	3,132	84.2	8.4	8.3	19.3	569
	Rome	4,551	81.8	10.6	7.4	22.7	961
Baited	Winesap	2,554	93.0	2.9	4.0	8.0	193
	Rome	3,794	92.6	4.3	3.3	8.4	314
Unbaited	Average	3,841	83.0	9.5	7.8	21.0	765
Baited	Average	3,174	92.8	3.6	3.6	8.2	254
Percent reduction in injury in baited area.				62.1	53.8	61.0	66.8

At the end of the first brood period the number of worm entrances per tree averaged 16 for the baited and 77 for the unbaited area. The rate of increase therefore was somewhat greater in the baited area later in the season probably as a result of migration from the unbaited to baited blocks. This being the first year's work in the orchard no previous record of the distribution of the population is available. Further tests will be necessary to determine if the reduction must be credited to the traps or to normal population differences. There was a marked difference in infestation on either side of the line dividing the two areas with a fairly uniform infestation within each area hence there is no reason to believe that the baits were not responsible for the differences shown.

Biological Studies

In studies of the distribution, survival, and development of the overwintering brood, pupation of native larvae reached 93 percent and emergence 74 percent by May 24. Emergence from 10 trees under observation was completed June 7. Emergence in cages was considerably in advance of natural conditions indicating the danger of placing too much reliance on records of development in artificial locations. It had reached 97 percent on May 24. Complete examinations of 5 trees and samples of the ground area underneath indicated that as in all preceding years except 1938, one-third or more of the surviving population was in the ground debris. In 1938 there was evidence of a considerable migration of larvae from overwintering cocoons on the ground to locations on the tree. Bands placed on a few trees early in 1939 showed that a limited amount of such migration took place this season both from ground debris to the trunk and from different parts of the tree to the band.

In egg studies on trees in the laboratory-field plots it was found that of 2,816 eggs observed at least 6.6 percent were destroyed, largely by chrysopid larvae within 5 days after they were deposited. In this period from 1.3 to 4.9 percent of the eggs scaled off on the different spray plots. Approximately 10 percent of the eggs could not be found until two or more examinations had been made where nicotine-bentonite or lead arsenate-bordeaux sprays were used. Eggs which were killed or injured by oil sprays remained in the red ring stage for a longer than normal period. Some of these injured eggs eventually hatched but the larvae were weak and stunted. After 5 days when some eggs began to hatch it was not possible to make certain of their fate. If they disappeared it could not be determined whether they were destroyed or had hatched before the shell came loose. It was certain, however, that the percentages which scaled off or were destroyed became greater as the eggs increased in age before hatching.

The examinations were made on low hanging branches where the exposure to rain, wind and sun was less than average. These factors through their effect on spray deposits and the eggs appear responsible for the loosening and dropping of eggs. Many eggs early in the season were deposited on small basal leaves which were dropped by apple scab before the eggs hatched.

BELTSVILLE, MARYLAND

E. H. Siegler, In Charge

Codling Moth Larval Attractants

A number of years ago the writer conceived a theory of combating the codling moth by stimulating surface feeding on the part of the newly-hatched larva. This conception was founded on the desirability of modifying the normal feeding habits of the larva to the extent that it would ingest a lethal dose of the insecticide previous to its attack on the skin of the apple. Also it was thought that by the use of a suitable attractant many larvae would probably be killed as a result of increased feeding on the foliage.

Until the present year, the results of experimentation have not appeared promising. We now have, however, data which indicate that the addition of certain compounds to the insecticide greatly increases the effectiveness of the latter under laboratory conditions (apple-plug method). Space does not permit a comprehensive discussion of the experimental data for which reason only a brief summary is herewith given.

Of the several compounds tested, brown sugar, because of its availability and low cost, appears to offer the most promise as a larval attractant. Its addition to lead arsenate, calcium arsenate, nicotine-bentonite, and phenothiazine considerably enhanced the toxicity of these insecticides. In combination with Paris green, its principal effect was in the reduction of stings. With pyrethrum, brown sugar was not notably effective and with derris it had no value. This may possibly indicate that derris and pyrethrum kill the codling moth larva largely by contact action.

The hexahydroxy alcohol, sorbitol, was used only with lead arsenate. This combination was markedly toxic. Other compounds which definitely improved the effectiveness of lead arsenate were sucrose, corn syrup, d-fructose, glycerine and malic acid. Although lesser differences in larval survivals resulted from the combination of lead arsenate with honey, dextrose, and galactose, these materials reduced appreciably the number of stings. Molasses, which was used only with nicotine-bentonite and phenothiazine, was helpful to these insecticides.

Summer-oil emulsion was tested in combination with brown sugar and lead arsenate because of its possible value in increasing the adherence of brown sugar and lead arsenate. This spray gave excellent results, indicating that the presence of summer-oil does not inhibit the attractiveness of brown sugar.

Throughout this study the data have shown that the percentage of stings was usually markedly reduced by the addition of a larval attractant to the insecticide. This is a good indication that the attractant stimulated the larva to consume a toxic dose of the poison before it attacked the skin of the fruit.

The reason why certain substances are effective as larval attractants is not known, but there is considerable indication that many materials which are sweet to our taste are also palatable to newly-hatched codling moth larvae.

During the course of the study it has been found that the presence of either bentonite or lime nullifies the effectiveness of brown sugar in combination with lead arsenate.

Some typical data of the more promising results obtained during the past year are given in Table 1.

Table 1.--Results of Laboratory Studies on Codling Moth Larval Attractants.

Spray Material Pounds per 100 Gallons	Number of Apple Plugs	Percentage of Apple Plugs		
		Wormy	Stung	Clean
Water (Check)	316	96.2	2.2	1.6
Brown sugar 16	215	93.4	1.4	5.1
Summer-oil emulsion 8	319	85.9	2.8	11.3
Lead arsenate 4	310	28.7	43.9	27.4
Lead arsenate 4) Summer-oil) emulsion 8)	311	23.8	18.6	57.6
Lead arsenate 4) Summer-oil em. 8) Brown sugar 16)	316	0.9	3.5	95.6
Water (Check)	105	96.2	1.9	1.9
Lead arsenate 4	107	33.7	19.6	46.7
Lead arsenate 4) Sorbitol (tech-) nical) 16	107	3.7	1.9	94.4

Table 1. (cont'd)

Spray Material Pounds per 100 Gallons		Number of Apple Plugs	Percentage of Apple Plugs		
			Wormy	Stung	Clean
Calcium arsenate	4	102	37.2	26.5	36.3
Calcium arsenate Brown sugar	4) 16)	105	7.6	11.4	81.0
Nicotine bentonite*		103	77.7	5.8	16.5
Nicotine bentonite* Brown sugar	16	105	10.5	1.9	87.6
Nicotine bentonite* Molasses	16	107	28.0	7.5	64.5
Phenothiazine	1	107	56.1	12.1	31.8
Phenothiazine Brown sugar	1) 16)	104	23.1	2.9	74.0
Phenothiazine Molasses	1) 16)	102	17.6	4.9	77.5

* Containing 0.025 per cent of nicotine.

Weathering of Chemically-Treated Codling Moth Bands

The study of the resistance to weathering of chemically-treated bands, variously treated, at the Beltsville, Md., laboratory was continued during 1939. This investigation was conducted by the so-called "post method" in which the bands were applied to round wooden posts, about 6 inches in diameter, instead of to trees. Posts provide greater uniformity than trees with respect to washing by rains.

During the period of exposure (July 1 to November 3) the total rainfall amounted to 12.79 inches.

A summary of the results (obtained gravimetrically) is given in Table 2.

Table 2. Weathering of Chemically-Treated Codling Moth Bands. Beltsville, Md.,193'

Chemical Treatment	No. of bands	Chemical load in ounces per foot	Percentage of chemical load lost
(Hot dipped)			
Beta naphthol (tech'l) - 1 lb. Oil (Lubricating) 300 S.U.V. - 1-1/2 pts.	5	0.31	48
ditto	5	0.40	54
ditto	5	0.51	56
(Hot dipped)			
Beta naphthol (tech'l) - 1 lb. Oil (lubricating) 100 S.U.V. - 1-1/2 pts.	5	0.32	59
ditto	10	0.40	65
ditto	5	0.47	67
ditto	5	0.72	58
(Hot dipped)			
Beta naphthol (tech'l) - 1 lb. Oil (lubricating) 100 S.U.V. - 1-1/2 pts. Aluminum stearate - 0.5 oz.	5	0.30	63
ditto	10	0.40	67
ditto	5	0.49	65
(Cold dipped)			
Beta naphthol (tech'l) - 1 lb. Oil (lubricating) 100 S.U.V. - 1-1/2 pts.	5	0.31	62
Diluted with gasoline			
ditto	10	0.40	58
ditto	5	0.49	58

The average loss of chemical load was as follows:

(Hot-dipped) B.N. + Oil 300 SUV ---------------- 52 per cent

(Cold-dipped) B.N. + Oil 100 SUV --------------- 59 per cent

(Hot-dipped) B.N. + Oil 100 SUV ---------------- 63 per cent

(Hot-dipped) B.N. + Al. St. + Oil 100 SUV ------ 66 per cent

An analysis of variance of the data, using these mean losses, and odds at 100 to 1, has shown that the first formula listed above was significantly better than any of the others in retaining its chemical load. The required difference for significance (3.6) was clearly exceeded in each comparison.

The cold-dip formula was barely superior to the hot-dip formula containing 100 viscosity oil (difference required for significance 3.3) but was significantly better than the hot-dip formula in which aluminum stearate and oil of 100 viscosity was used.

The mean difference between the two hot-dip formulas, one with and the other without aluminum stearate, is not significant.

(b) Xanthone

1. Xanthone 3.75 lb. per 100 Imperial gallons with ammonium oleate-zinc sulphate and with ammonium oleate-zinc sulphate-kerosene gave control results similar to the check materials (lead arsenate-casein-lime and cryolite-casein-lime) at similar concentration.

B. Control by Means Other Than Spraying

Nothing to report.

CANADA

Harold T. Stultz, Dominion Entomological Laboratory, Annapolis Royal, Nova Scotia.

I. Seasonal conditions and abundance of the insect during the 1940 season.

In the Annapolis Valley development during the early part of the 1940 season was delayed because of a cool April, the mean temperature being about 1.5 degrees less than average. Development proceeded rapidly during May which had a mean temperature nearly 3.5 degrees higher than average. The mean temperature for June, as a whole, was about average although the period between June 11th and 26th was, for the most part, cooler than usual. The mean temperature for July exceeded the average by about 2 degrees with the hottest period occurring July 25-29. August was slightly cooler than the average for the month. September was about normal.

In the earlier sections of the Annapolis Valley, the first McIntosh bloom appeared on May 29th. By June 3rd the bloom was just past its peak and on June 7th petal fall for this variety was practically complete. The Ben Davis was in full bloom on June 10th. The calyx cups of the Ben Davis were not quite closed on June 22nd.

Generally speaking the codling moth showed some increase over 1939 although we have records of decreased codling moth in individual orchards. In some orchards, which have not been sprayed for many years, there was a pronounced increase in injured apples while in others there was a definite decrease. In 1939 parasitism by Ascogaster carpocapsae was fairly high in orchards of this type showing a decrease in codling moth in 1940. The predator beetle, Tenebroides corticalis Melsh. was also quite abundant. Both these insects have increased in numbers during 1940. In several consistently unsprayed orchards at least 65 percent of the larvae are parasitized by A. carpocapsae. On the other hand, in one sprayed orchard, out of 1818 larvae collected in bands, 7.6% are parasitized by Ascogaster carpocapsae whereas, in 1939, there was less than one percent parasitism. No hyperparasites were recovered from 153 parasitized larvae collected in 1939.

In the most heavily infested orchard, the percentage of fruit entered was 96 percent for the McIntosh variety and 86 for Golden Russet with an average of over two entries per injured apple. This orchard was somewhat indifferently sprayed.

II. Studies on codling moth biology.

This is the first year that a life history study of the codling moth has been made in Nova Scotia. During 1940 rather close observations were kept on codling moth development in the above mentioned heavily infested orchard. The insect was also reared in the insectary. The first moths of the season were taken in bait pans and from rearing cages on June 10th. The peak of the catch in bait pans occurred during the second week in July. By July 26th, 85 percent, and by August 17th, 99 percent of the season's catch had been taken. The last moth of the season was caught September 6th. In the case of caged material the heaviest emergence occurred during the third and fourth weeks in June and by July 13th, 85 percent had emerged. None emerged in the cages after July 28th. Over-wintering cocoons were uncovered in the bark of trees from time to time in order to check on emergence. Approximately 15 percent of 261 over-wintering cocoons found on July 26th still contained living larvae or pupae. It will be noted that it was on this date that all but 15 percent of the total catch of moths in the bait pans had been taken.

Following the first appearance of codling moths there was a period of ten days or more before much egg laying occurred. This was probably due to the large percentage of male moths emerging at this time and the low sundown temperatures. The incubation period, in the insectary, varied from 8 to 13 days, being 12 to 13 days during the latter part of June, decreasing to 8 and 9 days for eggs hatching July 27th to August 4th, and increasing by the middle of August to 10 - 11 days.

The first side entry was found on July 3rd, the last fresh entry found was made about August 30th. Out of 2,964 entries recorded for two Golden Russet trees and one McIntosh, 85 to 90 percent were made between July 10th and August 21st. Approximately 8 percent had entered previous to July 10th. Larvae first entered tree bands some time between August 2nd and 5th. Eighty-three percent of the larvae entering bands, did so between August 12th and September 29th. Previous to August 12th 7.5 percent had entered the bands.

In the insectary the larval feeding period varied from 23 to over 60 days, with 73 percent taking 28 to 41 days, 15.87 percent taking 42 to 50 days and only 2.8 percent taking less than 28 days. None of the insectary reared larvae pupated in 1940. In the field there was no evidence of a second generation. Out of 1818 larvae taken from bands this season, not one pupated. The uncovering of several hundred 1940 cocoons from trunks of heavily infested trees during August did not disclose any evidence that larvae were pupating. It is possible, of course, that an earlier season might cause larvae to pupate and start the development of a second generation.