Table 3.—Codling Moth Infestation at Harvest, 1941 and 1942

Material per 100 gal.		Per Cent of Fruits Stung	Wormy
1941			
4 Sprays arsenate of lead	3.3 lb.		
"Fluxit"	0.2 lb.		
2 Sprays "Alorco" synthetic cryolite	3.75 lb.	9.8	10.9
"Fluxit"	0.2 lb.		
3 Sprays arsenate of lead as above			
3 Sprays micronized phenothiazine	1.8 lb.		
Monoethanolamine oleate	0.5 lb.	5.6	9.8
Stove oil	0.25 gal.		
1942			
Arsenate of lead and cryolite as in 1941		1.8	3.5
Phenothiazine as in 1941 throughout the season except arsenate of lead in calyx spray		.9	1.4

No check was made for differences in size or color of fruit between the phenothiazine and standard schedule plots, but general observation throughout the season and at the time of examining the fruit at harvest revealed no marked differences. Superiority in this regard lay, if anything, with the phenothiazine. An undesirable feature of phenothiazine is that it causes irritation of the skin similar to sunburn. The lips are particularly affected. In 1941, girl thinners working in Keloka orchards the day following spraying had to be removed because of irritation to arms and face. Men thinners were not affected.

PREVENTION OF FRUIT DEVELOPMENT AND ITS EFFECT ON THE SURVIVAL OF THE CODLING MOTH

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In recent years considerable attention has been given to the possibility of spraying apple trees to destroy the blossoms without causing other injury. This procedure has been undertaken for the following purposes: (1) to eliminate a portion of the crop and so overcome the alternate bearing habit, (2) to thin the crop and so increase the size of the fruit left on the tree, and (3) to control certain orchard insects, particularly the codling moth. The practice of blossom removal by spray applications has been referred to as "deblossoming", a term which will be used here because it is concise and expressive.

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Review of the Literature

As yet, few definite recommendations have been made on deblossoming sprays. Holbeche (1941) found that 2 per cent "cresol" or 3 per cent tar-oil gave the most satisfactory results in removing an unprofitable crop. Gardner et al. (1939) in endeavoring to thin the apple crop by spraying at bloom period, used at 0.25 per cent to 0.5 per cent concentration, a commercial petroleum oil spray containing 4 per cent 2, 4-dinitro-6-cyclohexylphenol. The treatments were effective and appeared to cause no permanent injury to Duchess, Wealthy and Ontario apple trees. Results of five seasons' experiments by Shepard (1939) showed that 2 per cent cresylic acid and 3 per cent tar-oil were effective in destroying the blossoms of Beach, Champion, Willow Twig, York and Jonathan varieties and

there was no indication of persisting injury. Read (1941) found that 1 per cent cresylic acid gave the best results. Unsatisfactory results were obtained by Auchter and Roberts (1933) using lime sulphur, copper sulphate, sodium nitrate, sodium polysulphide and zinc sulphate. Magness et al. (1939) experimenting with 2,4-dinitro-6-cyclohexylphenol and tar oil showed that one application completely killed almost all the blossoms on Winesap, Delicious and Grimes. One year's observation by Harley and Moore (1940) indicated that 2 per cent tar oil applied at the rate of 60 to 70 gallons per tree during late cluster-bud stage resulted in 96 per cent blossom removal on Delicious, Winesap, King David and Stayman.

Since it has been commonly felt that early removal of the crop would at least reduce the population of the codling moth to a very low level, it seems logical to assume that deblossoming sprays might be useful in controlling this insect. The literature on the subject suggests that the value of bloom-killing sprays in codling moth control would depend upon (1) the percentage of the larvae that live two winters before emerging as moths and (2) the importance of fruit to survival of the codling moth.

Regarding the possibility that this insect may remain in the larval state for two winters, Yothers and Carlson (1941) during the period July 6 to November 10, 1939, found thousands of larvae still alive in their cocoons in the soil at or near the base of apple trees bearing practically no crop. As some of these specimens were observed before many of the "first brood" larvae had left the fruit on adjacent trees, it was concluded that they must be non-transforming larvae remaining from the previous (1938) season. The possibility that these larvae may have matured on other tissue than fruit is not mentioned. Brodie (1906) reported that a few codling moth larvae which cocooned July 1905, remained unchanged October 1906 and stated that "moths would not emerge from these until the spring of 1907." Whether or not he succeeded in rearing the moths during 1907 is not known. Survival of a very small number of "two-year" larvae was noticed by Hammar (1912), Siegler and Brown (1928), and Longley (1921), but none of these workers succeeded in rearing moths from them. Wakeland and Rice (1932) report that "a few individuals studied required more than a year to complete their life cycle," but no data are included to support this statement. Thus as far as can be learned from the literature, there is no conclusive proof that codling moth larvae may survive two winters and subsequently perpetuate the species.

The second important point in considering the usefulness of crop removal measures in codling moth control is to know whether or not this insect can complete its life cycle in the absence of fruit. In the laboratory, Heriot and Waddell (1942) and Speyer (1932), were successful in rearing moths from larvae fed on leaves alone, but the moths derived were unusually small, short-lived specimens, and produced no eggs. Hall (1928) also succeeded in rearing larvae to maturity on apple leaves but they failed to pupate. Under field conditions, Marshall (1940) observed that large numbers of larvae developed to maturity on a caged Benoni apple tree from which the crop was removed. Newly-hatched larvae, not finding any fruit, fed on fruit buds and spurs, sap shoots, leaf bases, new breaks in twigs and small branches (4-year old wood), enlargements caused by the feeding of woolly aphids, and leaves alone. Hundreds of these larvae matured and entered bands on the tree trunk in the fall but Marshall does not say whether or not they pupated the following spring. Spur-burrowing in Anjou and Bosc pear fruit spurs by codling moth larvae is reported by Gentner (1940) as a common occurrence in Rogue River Valley, Oregon. The young larvae burrow into fruit spurs with fruit attached,

during both the first and second brood periods. Larvae were found to complete their development and transform to moths but their capability for producing fertile eggs is not mentioned. Although it is probable that the codling moth can perpetuate the species in the absence of fruit, this point apparently has not yet been established with certainty.

To determine the feasibility of removing an apple crop by chemicals and to determine further the value of such a procedure in control of the codling moth, co-operative projects were undertaken by the British Columbia Department of Agriculture and the Vernon Laboratory of the Division of Entomology, Dominion Department of Agriculture.

Experiment on the Killing of Apple Blossoms

On April 29, 1942, a block of 121 Jonathan and Grimes' Golden trees at Okanagan Centre was sprayed in the pink stage when many blossom clusters were not separated. A portable two-gun sprayer regulated at 500 pounds pressure was used. Disc apertures were 7/64 inch. The block of trees was divided into six plots which were sprayed with the following materials:

Table 1. Plots and Spray Materials Used in Apple Deblossoming Experiment.

Plot	Materials per 100 Imperial gallons		Amount of spray per box capacity of tree
1	"Dowspray Dormant" (1)	1.0 gal.	0.25 gal.
	Lignin pitch (2)	4.0 oz.	
2	"Dowspray Dormant"	1.5 gal.	0.25 gal.
	Lignin pitch	4.0 oz.	
3	"Dinitro Dry" (3)	1.2 lb.	0.75 gal.
	Oil - 117 S.S.U., 64% U.R., (Mid - continent crude)	1.0 gal.	
	Lignin pitch	4.0 oz.	
4	"Dinitro Dry"	1.8 lb.	0.75 gal.
	Oil - 117 S.S.U., 64% U.R., (Mid-continent crude)	1.5 gal.	
	Lignin pitch	4.0 oz.	
5	"Dinitro Dry"	1.8 lb.	0.75 gal.
	Oil - 245 S.S.U., 62% U.R., (Calif. crude)	1.5 gal.	
	Lignin pitch	4.0 oz.	
6	"Dinitro Dry"	1.8 lb.	0.75 gal.
	Lignin pitch	4.0 oz.	

(1) "Dowspray Dormant" Manufacturer's analysis: dormant oil 100-110 S.S.U. (Mid-continent crude) and 2,4-dinitro-6-cyclohexylphenol 4 per cent by weight.

(2) "Copacite", a by-product of the calcium bisulphite paper making process.

(3) "Dinitro Dry" Manufacturer's analysis: 4,6-dinitro-ortho-cresol 50 per cent, inert material [bentonite?] 50 per cent.

Examination of these plots on May 14, showed that the trees in plots 1 and 2, which were lightly sprayed with 2,4-dinitro-6-cyclohexylphenol - oil mixture, had less than 20 per cent of the blossoms killed and only a small amount of foliages injury. Trees in plots 3, 4, 5 and 6, which received a thorough spray application of 4, 6-dinitro-ortho-cresol either alone in water or with oil, had 80 to 95 percent of the blossoms killed. At the same times, however, a considerable number of fruit spurs were killed, so for blossom-removal the treatments appear to be too radical. Since the lightly sprayed trees in plots 1 and 2 were evenly thinned without serious spur damage, further work with dinitrophenol derivatives is planned by the British Columbia Department of Agriculture in order to determine if chemical thinning is practicable.

Experiment on the Effects of Blossom Removal on Codling Moth Infestation the Following Year

To determine the value of deblossoming sprays in codling moth control an experiment was commenced at Oyama, B.C., during 1941. About one-half acre of 20 to 30-year old McIntosh, Wealthy, and Delicious apple trees, some 300 yards from the nearest orchard, was sprayed in the pink stage with a 2 per cet emulsion of high-boling, neutral tar oil. Emulsification was accomplished by lignin pitch. The centre McIntosh blossoms were just opening, but the Delicious and Wealthy blossom clusters were not all separated, so in view of evidence in

the literature, the spray was probably applied somewhat too early for best results, with these varieties. Application was thorough, approximately one gallon of spray being applied per box of fruit that the trees were capable of bearing. About 90 per cent of the blossoms were killed by the spray. During June, fruits which set were removed by hand before any first generation larvae had matured. Dropped fruits were also collected and destroyed.

As far as could be determined, no worms developed in apples in this block of trees in 1941. Nevertheless, after half an hour's examination by three men on April 17, 1942, 7 larvae and one pupa were found beneath bark scales near the base of the trees. This material was caged in the laboratory and 7 moths emerged from it during the following May and June. While it is probable that these moths developed from two-year-old larvae, there is yet a possibility the larvae developed during the previous season (1941) on the trees devoid of fruit.

The trees were not sprayed in 1942 and when examined at harvest, the light crop was found to be heavily infested. Fruits on McIntosh, Wealthy and Delicious trees were 65, 85 and 90 per cent wormy respectively. The infestation may not have resulted entirely from hibernating larvae in the treated orchard for it is possible that moths immigrated from surrounding infested orchards. The main point is that although crop removal was more thorough than would have been accomplished by most growers, it did not prevent a ruinous attack by codling moth the following year. Accordingly, deblossoming or other means of crop removal apparently cannot be considered a procedure worthy of recommendation for control of this insect in a two-generation area such as the Okanagan Valley. Perhaps, however, it may be found feasible to employ a deblossoming spray under certain circumstances as a supplementary control measure.

Summary

Results from deblossoming sprays may vary greatly according to variety of apple, climate, date of application and thoroughness of spraying. A pink spray of 2, 4-dinitro-6-cyclohexylphenol with oil emulsion, or 4, 6-dinitro-ortho-cresol either alone in water or with oil emulsion, destroyed a considerable number of fruit spurs when used at concentrations high enough to produce satisfactory killing of Jonathan and Grimes' Golden apple blossoms. Low concentrations of these substances, however, evenly thinned the crop without obvious spur injury. So far no chemical has been demonstrated capable of completely destroying apple blossoms without the likelihood of serious injury to fruit spurs.

In codling moth control the importance of deblossoming sprays or other means of crop removal appears to depend on the percentage of larvae in an orchard that live two winters before emerging as moths and upon whether or not the codling moth can survive on tissue other than fruit. Deblossoming McIntosh, Delicious and Wealthy apple trees with a tar-oil spray and subsequent removal of any developing fruit did not prevent heavy infestation by codling moth the following year in a two-generation area of the Okanagan Valley.

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CRYOLITE VERSUS LEAD ARSENATE FOR CONTROL OF CODLING MOTH *

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In 1939, cryolite was recommended for late codling moth spray applications in the interior of British Columbia. The purpose of the recommendation was to avoid heavy deposits of lead arsenate. A number of growers who have not accomplished satisfactory control of the codling moth since that time have blamed cryolite for their failure. Their distrust of cryolite has been increased by the appearance of the diluted spray mixture, as it resembles muddy water rather than spray material. Then too it leaves a less obvious deposit than lead arsenate. But the chief reason for unfavorable opinion results from the time of application, since it is more difficult to prevent codling moth entries during July when cryolite is used than during May and June when lead arsenate is applied. Furthermore, for every larva attempting to enter the fruit in May or early June, there may be twenty-five or more attempting to enter in July and August. A review of the investigations that serve as a basis for the cryolite recommendation will therefore be timely.

First it will be well to examine some of the work that has been done with cryolite in the neighboring state of Washington. This is summarized in Table I.

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