THE EUROPEAN WINTER MOTH AS A PEST OF FILBERTS: DAMAGE AND CHEMICAL CONTROL[1]

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ABSTRACT

Different chemicals and two spray timing dates were evaluated for control of the European winter moth, *Operophtera brumata* (L.) in filbert orchards of Oregon. Data showed that endosulfan, carbaryl, phosalone, diazinon and fenvalerate were effective against this pest. A *Bacillus thuringiensis* product, Thuricide HPC was found to be ineffective. The timing of the spray treatment was critical. Sprays applied at 90 - 95% egg hatch (April) were much more effective than the sprays applied at 50 - 60% egg hatch (March). The spray timing seemed to be less critical for fenvalerate treatment, which was equally effective at both treatment dates.

The damage caused by *O. brumata* to filbert trees is described.

INTRODUCTION

The European winter moth, *Operophtera brumata* (L.), is a common pest of tree fruits in most of Europe and parts of Asia. It is widespread across northern Africa, temperate Eurasia from Scandinavia, Britain and France to Japan (Ferguson 1978). It was first recorded from North America in Nova Scotia in 1949 (Smith 1950), although there is strong indication that the pest might have been introduced to that province some time before 1930 (Cunningham *et al.* 1981). In the Pacific Northwest, the first introduction was detected in 1976 on southern Vancouver Island, B.C. (Gillespie *et al.* 1978), and by 1978 near Portland, Oregon. However, a close examination of insect collection records from Oregon indicates that several males of *O. brumata* had been collected in 1958 and later in 1973 from Oregon locations (Ferguson 1978).

The biology of *O. brumata* has been studied by a number of workers including Cumming (1961), Embree (1965, 1970), and Smith (1950) from Nova Scotia, Gillespie *et al.* (1978) from British Columbia, and J.C. Miller (personal communication) from Oregon. Miller has shown that *O. brumata* is well distributed throughout the northern Willamette Valley, Oregon and seems to prefer cultivated filberts (hazelnuts), *Corylus avellanae* L., although large populations were also noticed on *Prunus* (plum), *Malus* (apples), *Pyrus* (pear), and *Quercus* (oak) species. AliNiazee (1981) reported *O. brumata* as a new pest of commercial filberts in the Willamette Valley. Reported here are studies evaluating the effect of spray timing on the efficacy of some commonly used filbert insecticides against *O. brumata*. Damage caused on filbert trees is also described.

MATERIALS AND METHODS

Studies were conducted in a filbert orchard, heavily infested with winter moth, located in Washington County, Oregon. The orchard consisted of two (one with 12-year-old and the other with 30 - 40-year-old) tree blocks, approximately 4 ha each. The present study was conducted in the young tree block (consisting of mostly Barcelona and Daviana varieties) because of its convenience for spraying and sampling. The damage observations were conducted by collecting and examining 50-100 opening buds or terminals at weekly or biweekly intervals throughout the months of April, May and June. In 1981, four insecticide treatments (endosulfan, phosalone, carbaryl, and *Bacillus thuringiensis*) were compared with untreated checks, and in the 1982 season, five insecticides (endosulfan, phosalone, carbaryl, diazinon, and fenvalerate) were tested. Only those compounds which were registered for use in filbert system were selected for this study. The effects of different spray dates on the efficacy of the treatments were determined by applying chemicals at two different times: March 20 and April 3 in 1981; and March 29 and April 21 in 1982. These dates were selected to correspond with approximately 50-60% and 90-95% egg hatch in the field. The experimental plots were set up in a randomized block design with single tree plots separated by an unsprayed guard tree on all four sides to avoid spray drift. Each treatment was replicated four times. Sprays were applied during the early morning hours (6:00-10:00 a.m.) using a power sprayer with hand gun at a pressure of 250-300 p.s.i. Trees were sprayed to the point of drip, and *ca.* 6-8 liters of spray material was applied/tree.

Pre- and post-treatment counts were made by selecting 10 opening buds or terminals/tree at random at a height of 1.5-2.0 m above ground, approximately at the mid-canopy. These terminals were then brought to the laboratory and examined under a binocular microscope for winter moth damage. Data were analyzed using ANOVA and the means were separated using Duncan's Multiple Range Test.

Fig. 1. Shot-hole leaf feeding damage caused by *O. brumata*.

RESULTS AND DISCUSSION

Damage. The damage caused by the winter moth larvae on filbert trees resembles that of other native geometrids, including the western winter moth, *Operophtera occidentalis* (Hulst) and the Danby's winter moth *O. danbyi* (Hulst). However, both of these species are less common on filberts, and were rarely found in the present study. On the contrary, almost all early season damage in the study orchards was caused by *O. brumata*. The seasonal cycle of *O. brumata* appears to be well synchronized with the development of filbert trees, making it the most easily accessible plant for larval damage early in the season.

The larval damage caused by *O. brumata* was visible as early as middle to late March during 1981 and 1982, and continued for another 6-8 weeks. The early damage was caused by indiscriminate larval feeding on opening buds in March. Larvae made holes in and fed on the bud material by boring inside. Both vegetative and fruiting buds were affected. As the season progressed, the larvae started to feed on young and newly opened leaves thus causing a shot-hole effect. (Fig. 1). At this stage, their feeding damage resembled the damage caused by another insect, the Syneta beetle *Syneta albida* Lec., which appears in the orchards slightly later. The winter moth damage became more pronounced as the trees started to grow and form a canopy. Heavily infested trees were generally full of leaves with holes, and were unable to provide any shade. Eventually these leaves withered away and fell, causing defoliation (Fig. 2).

Chemical Control. Data (Tables 1 and 2) show differential susceptiblity of winter moths to different test chemicals. An examination of the results of different treatment dates suggests that timing appears to be a critical factor in chemical control of this pest. For example, in 1981 trials, the first spray applied on March 20 provided inadequate control (Table 1). Although the infestations were noticeably reduced in all treatments except *Bacillus thuringiensis* (formulation Thuricide HPC), the control achieved was inadequate to reduce damage. However, performance of the same insecticides improved substantially when they were applied on April 3, about two weeks after the first treatment (Table 2). Among the chemicals tested in 1981 (Table 2) endosulfan provided excellent control, followed by carbaryl and phosalone. The microbial insecticide *Bacillus thuringiensis* was less effective in both early and late treatments, although its performance also improved in late treatment plots.

In 1982, two additional chemicals, diazinon and fenvalerate were included in the trial and *B. thuringiensis* was deleted because of its ineffectiveness in 1981 trials. Data (Table 3) indicate that endosulfan and fenvalerate both performed extremely well; the infestation was reduced from 15% in control to 0% in treated plots. Other tested chemicals, diazinon, carbaryl and phosalone provided moderate control. However, statistically non-significant differences were found among these treatments. Late

TABLE 1. Efficacy of early treatment (March 20) of some selected insecticides against *Operophtera brumata* in filberts. Washington County, Oregon, 1981.

Chemicals	Dosage lb AI/100 gal	Percent Infestation of terminals after treatment[1,2] 7 days	17 days	24 days
endosulfan 50 WP	0.5	15.0 ab	7.5 ab	0.0 a
carbaryl 50 WP	1.0	7.5 a	2.5 a	2.5 a
phosalone 3 Ec	0.5	15.0 ab	15.0 ab	10.0 ab
Thuricide HPC	1/3 qt[3]/	40.0 b	10.0 ab	10.0 ab
Untreated check	---	27.5 b	27.5 b	15.0 ab

1/ Means followed by same letter are not significantly different (P = .05) using Duncan's Multiple Range Test.

2/ Pooled pre-treatment count conducted on April 3 showed 50 $\pm$5 SD percent of the terminals were infested and that the infestation was very uniform throughout the study blocks.

3/ Actual formulated material.

TABLE 2. Efficacy of late treatment (April 3) of some selected insecticides against *Operophtera brumata* in filberts. Washington County, Oregon, 1981.

Chemicals	Dosage lb AI/100 gal	Percent Infestation of terminals after treatment[1,2]		
		7 days	17 days	24 days
endosulfan 50 WP	0.5	0.0 a	0.0 a	2.5 a
carbaryl 50 WP	1.0	2.5 ab	2.5 ab	2.5 a
phosalone 3 EC	0.5	10.0 ab	5.0 ab	7.5 ab
Thuricide HPC	1/3 qt[3]	17.5 b	20.0 bc	22.5 b
Untreated check	---	50.0 c	27.5 c	17.5 ab

1/ Means followed by same letter are not significantly different (P = .05) using Duncan's Multiple Range Test.

2/ Pooled pre-treatment count conducted on April 3 showed 50 $\pm$ 5 SD percent of the terminals were infested and that the infestation was very uniform throughout the study blocks.

3/ Actual formulated material.

TABLE 3. Influence of different treatment dates on efficacy of some selected insecticides against *O. brumata* in filberts. Washington County, Oregon, 1982.

	Dosage	$\bar{x}$ Percent infestation on indicated dates 1/			
		Early treatment 2/		Late treatment 2/	
Chemicals	lb AI/100 gal	Pre-treatment (3-29)	Post-treatment (4-20)	Pre-treatment (4-21)	Post-treatment (4-29)
endosulfan 50WP	0.5	22.5 a	0.0 a	10 a	0.0 a
carbaryl 50 WP	1.0	27.5 a	2.5 a	15 a	3.0 a
phosalone 3 Ec	0.5	27.5 a	7.5 a	10 a	3.0
Diazinon 50 WP	0.5	17.5 a	2.5 a	10 a	0.0 a
fenvalerate 2.4 Ec	0.2	20.0 a	0.0 a	10 a	0.0 a
Untreated	---	20.0 a	15.0 b	10 a	10.0 b

1/ Means followed by same letter are not significantly different (P = 0.05) using Duncan's Multiple Range Test.

2/ Early treatment applied March 29, 1982 and late treatment April 21, 1982.

Fig. 2. Defoliation of a filbert tree branch caused by *O. brumata*.

treatment applied on April 21 did reduce the infestation in almost all treated plots; the performance of endosulfan, fenvalerate and diazinon was slightly better than carbaryl and phosalone, although the differences among treatments again were non-significant. The time of the spray application had little affect on fenvalerate treatment. Since this synthetic pyrethroid is extremely effective and long-lasting, the spray timing seems to be less important than it was with the other compounds.

Treatment timing is a critical factor in determining the performance of insecticide sprays in all crop systems. Improper timing causes ineffective control. The early spray in 1981 was applied at about 50% egg hatch, and the late spray at about 90% egg hatch. In 1982, the early spray was applied at about 60-65% egg hatch and the late spray near 100% egg hatch. Most growers with *O. brumata* tend to apply their control treatments as early as possible (preferably in late March and early April), to avoid initial bud damage. Data presented here suggest that although the early treatments would reduce *O. brumata* populations markedly, they would be ineffective in controlling late emerging larvae. It appears, therefore, that spray application during the first two weeks in April (depending upon the spring temperatures), which corresponds to the late treatment date of this study, might provide better control using the same chemicals. This later date would coincide with about 90-95% egg hatch in most years. Since the early damage is generally insignificant, it seems that filbert growers can benefit by waiting until most eggs have hatched before applying chemical treatments for *O. brumata* control.

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RESPONSES TO PLANT EXTRACTS OF NEONATAL CODLING MOTH LARVAE, *CYDIA POMONELLA* (L.), (LEPIDOPTERA:TORTRICIDAE:OLETHREUTINAE)

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ABSTRACT

A bioassay was designed to test behavioral responses of neonatal codling moth larvae to chloroform and methanol extracts of 25 plant species. Chloroform extractable materials from absinthe wormwood, *Artemisia absinthium* (L.), rabbitbrush, *Chrysothamnus nauseosus* (Pallas), and tansy, *Tanacetum vulgare* (L.) showed promise as possible feeding deterrents to neonatal codling moth larvae.

INTRODUCTION

In Washington State approximately half the cost of controlling arthropod pests in apples is attributable to the codling moth, *Cydia pomonella* (L.) (Ferro *et al.* 1975). Much of the damage occurs as "stings" made by probing neonatal larvae attempting to penetrate but then not entering the fruit. This "stinging" behavior might be linked to incompletely developed chemoreceptors. Immediately upon eclosion from the egg, larvae may not be able to recognize the fruit as a potential food source. This "non-recognition" phenomenon has been shown by Wiklund (1973) for early instars of *Papilio machaon* (L.) and by Bland (1981) for first instars of acridids. Non-recognition of food by neonates can lead to wandering activities that increase their exposure to abiotic and biotic mortality factors. As a result, in unsprayed apple orchards, death of neonatal codling moth larvae reduces the population by greater proportions than mortalities of any other life stage (Ferro *et al.* 1975, MacLellan 1977). Therefore, new control efforts should be directed to this stage. Disruption of larval feeding behavior by the use of secondary plant compounds may increase wandering and thus mortality.

We surveyed local plants for extracts that might modify the feeding behavior of neonatal codling moth larvae. Extracts that prevented or interrupted feeding activity were considered possible sources for feeding deterrents as defined by Schoonhoven (1982). Twenty-five selected plant species of eastern Washington and northern Idaho were collected in the survey. This study concentrated on neonatal larvae and their feeding behavior rather than on the long-term development of insects fed on artificial diets containing the suspected feeding deterrents.

MATERIALS AND METHODS

Plant Collection and Extraction

Test plants were collected during the summer of 1982. Criteria used to select the plants included strong odor, notable lack of herbivore feeding activity, or literature references concerning their repellent properties. An effort was made to include at least one representative from each of a variety of plant families (Table 1).

Plants chosen appeared healthy and free from visible signs of disease. Entire plants were collected including a moist ball of soil around the roots. The roots were wrapped in moist paper towels and covered with a plastic bag for transport. Plant samples were either frozen or extracted within 1 h of collection.

Ten grams of leaves (and flowers, if present) were weighed, wrapped in plastic, and frozen at ca. -16°C to preserve plant components without changes in chemical composition due to enzymatic activity (Draper 1976).

[1] Washington State Univ., College of Agriculture and Home Economics Research Center, Scientific Paper 7027. Work done under project number 5405.