EFFICACY OF *BACILLUS THURINGIENSIS* AND DIFLUBENZURON ON DOUGLAS-FIR AND OAK FOR GYPSY MOTH CONTROL IN OREGON[1]

by Jeffrey C. Miller and Kenneth J. West

Abstract. The insecticides *Bacillus thuringiensis* (Bt) and diflubenzuron (DFB) were tested for the effect of killing second instar gypsy moth larvae on foliage of Douglas-fir and Oregon white oak. Larval mortality differed significantly between the insecticides and check treatments. No significant differences in larval mortality were observed after one treatment of Bt or DFB, or after two treatments of Bt. No significant differences were noted between larval mortality on the foliage of either host plant. Effects of the insecticides were apparent 64 days post-application for all treatments.

Résumé. L'insecticide, le Bacillus thuringiensis (Bt) et le Diflubenzuron (DBF) furent testés afin d'évaluer leur efficacité pour tuer la spongieuse (à son deuxième stade larvaire) sur le feuillage du sapin de Douglas et du chêne blanc de l'Orégon. Le taux de mortalité des larves différait de manière significative entre les insecticides et les divers traitements. Aucune différence significative du taux de mortalité des larves ne fut observée après un traitement au Bt ou au DFB, ou après deux traitements au Bt. Aucune différence significative ne fut remarquée entre le taux de mortalité de la larve sur le feuillage des deux espèces hôtes. Les effets des insecticides furent apparents 64 jours après l'application de chaque traitement.

The gypsy moth occurs in western North America in scattered locations from southern California to British Columbia. Eradication efforts to rid this region of the gypsy moth typically employ chemical insecticides. In the past carbaryl has been used but presently *Bacillus thuringiensis* Berliner (Bt) and diflubenzuron (DFB) are likely to be two of the insecticides that may be used in future eradication efforts. Data are needed on the efficacy of these compounds under western conditions.

The objective of our study was to assess the efficacy of ground applied Bt and DFB in controlling gypsy moth larvae, with particular attention given to the length of time the compounds remained active under field conditions. Spraying from the ground, as opposed to aerial sprays, is the primary method of application for homeowners and for the eradication/control of gypsy moths in small, localized sites. We also wanted to compare the efficacy of these compounds when applied to the foliage of a broadleaf and coniferous trees. The principal oak species in the Pacific Northwest is Oregon white oak, *Quercus garryana,* a tree of great value to homeowners and commercial woodlot operators. The most important conifer, Douglas-fir, *Pseudotsuga menziesii,* is a valuable tree for timber and widely planted in Christmas tree plantations.

Twenty Oregon white oak and 20 Douglas-fir trees were selected as the host plants for a bioassay using freshly molted second instar gypsy moths. The oaks were located at the edge of a 50 ha. oak woodland. The Douglas-fir were part of a 1 ha. Christmas tree plantation. Both sites were on gradual, west facing slopes and were located four km apart. Neither site had been subjected to insecticide use within the previous ten years.

Individual trees were selected using the criteria of: 1) ease of access for chemical application and sampling, 2) equal size and foliage density, and 3) avoidance of intertreatment drift. Five trees of each species were randomly assigned to each of four treatments: 1) a single application of Bt, 2) two applications of Bt (the first at the same time as in the single treatment and the second two weeks later), 3) a single application of DFB, and 4) untreated check trees.

The initial treatments occurred on May 6, 1986 at Corvallis, Oregon. At this time the oak foliage was fully expanded and the Douglas-fir buds had broken. Treatments were applied using a CO_2 powered backpack sprayer. We used Bt (Dipel

1. This article reports the results of research only. Mention of a proprietary product or pesticide does not constitute an endorsement or a recommendation for its use by Oregon State University. Oregon State University, Agricultural Experiment Station Technical Paper No. 8261.

32® , Abbott Laboratories, North Chicago, Illinois 60064) at a concentration of 4.22 BIU per liter (16 BIU/gal) and DFB (Dimilin 25W® , Uniroyal Chemical Co., 1625 East Shaw Ave., Fresno California 93710) at a concentration of 15ml per liter. Both compounds were applied at a "dose" of complete foliage wetting defined as until they dripped from the foliage.

Larvae for the bioassay were obtained from eggs collected in Lane Co., Oregon during October, 1985. The eggs were chilled until needed for the bioassay tests. First instars were fed artificial diet (Bioserv #963L1, gypsy moth diet) until they molted to the second instar. A cohort of second instar larvae, between 8-24 hrs. post molt, was selected for placement onto the sample foliage.

A total of 40 foliage samples were obtained on each test date (1 day prior to treatment and 1, 6, 14, 21, 28, 47, 58, and 64 days post-treatment). Larvae were reared on foliage from the pre-treatment sample to insure that the trees chosen were suitable. Each sample consisted of a single sprig of foliage (5-10cm.) clipped from each of the trees on each sampling date.

Individual bioassay units were constructed by placing a sprig of foliage in a tube with water and five second instars into a one-pint cup, replicated five times (n=25 per observation). The foliage was removed and the larvae were checked for mortality. After three days the foliage was removed and the surviving larvae were thereafter fed an artificial diet. The larvae were then observed for mortality on days: 7, 14, 21 and 28 after field collection of foliage. Observations on each sample were ended after 28 days. The observations on mortality did not change after 21 days. Thus, the data considered mortality that occurred over a three week period and were analyzed by a FPLSD test for statistical significance.

Weather conditions were monitored by measuring high and low temperatures and rainfall during the sampling period.

The weather data show that a wide range of conditions occurred during the study (Fig. 1). In general, the sprayed foliage was subjected to conditions of heavy rainfall, extended periods of sunlight, very warm daytime temperatures and crisp, cool night temperatures.

The results of the bioassays are presented in Table 1. Larval mortality in the oak and Douglas-fir treatments was not significantly different ($p < 0.05$, FPLSD) and are presented separately to demonstrate the consistent results among the applications of pesticides. These results are in opposition to trends found in other studies on different plant species. Morris (4) observed that Bt was more effective on foliage of deciduous species. Also, Maksymiuk (3) reported the reduced efficacy of Bt on conifers.

The most obvious trend in the data is that of the differences between the check (no spray) foliage

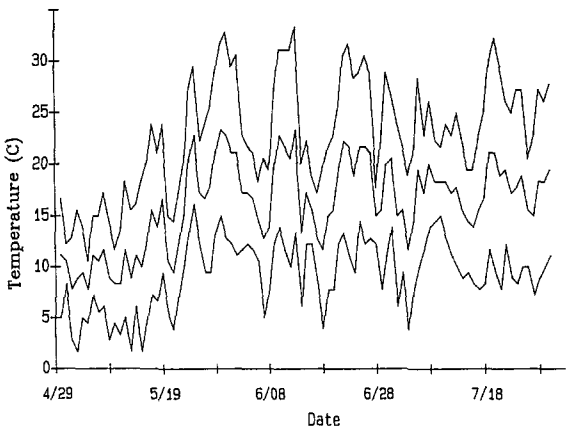

Fig. 1. Occurrence of maximum, mean, and minimum daily temperatures (°C) during the study period. Corvallis, Oreg. 1986.

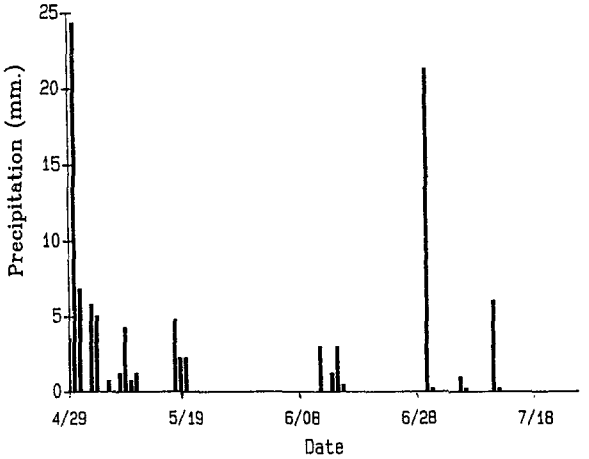

Fig. 2. Occurrence of measurable precipitation (mm) during the study period. Corvallis, Oreg. 1986.

Table 1. Mortality (%) of second instar gypsy moths on foliage of Oregon white oak and Douglas-fir treated with *Bacillus thuringiensis* Berliner (Bt) or diflubenzuron (DFB). Ground sprayed to point of drip. Corvallis, Oregon 1986.

Treatment[1]	*Sample date post treatment (days)*[2]							
	1	*6*	*14*	*21*	*28*	*47*	*58*	*64*
Oregon White Oak								
check	0a	0a	12a	48a	20a	28a	8a	56a
Bt once	100b	100b	100b	100b	100b	100b	100b	100b
Bt twice	100b	100b	100b	100b	100b	100b	100b	100b
DFB once	100b	100b	96b	100b	84b	100b	80b	100b
Douglas-fir								
check	0a	0a	8a	64a	16a	4a	12a	54a
Bt once	100b	100b	100b	100b	100b	88b	88b	96b
Bt twice	100b	100b	100b	100b	100b	100b	100b	88b
DFB once	100b	100b	100b	100b	84b	76b	92b	92b

[1] n = 25 larvae per treatment-sample day. Applied at a concentration of: Bt 4.22 BIU/1; DFB 15ml/1.
[2] days are time of foliage collection post treatment. Different letters within a column designate significantly different results, LSD-test, p ≤ 0.01.

and treated (Bt and/or DFB) foliage. No significant differences in larval mortality occurred between the Bt or DFB treatments (p 0.05, FPLSD). Larval mortality over time (up to samples taken 64 days post last spray) remained high throughout the term of the study. The longevity of residual activity is likely attributed to the application of material to the point of drip and, in the case of Bt, the relatively high dosage (16 BIU) and the presence of molasses in the formulation (2). Yendol et al (5) noted molasses added to Bt increased the amount of foliage consumed by larvae, thus resulting in a higher number of Bt spores ingested.

Larval mortality in the check plots precluded the conduct of a longer study. At the point of 64 days post treatment mortality was 56% and 54% among the check larvae on oak and Douglas-fir, respectively. Larval mortality in subsequent samples was even higher and thus not included in the analysis. We suspect the relatively high larval mortality in the check on day 21 was due to a weak cohort of larvae used in that trial.

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