Control and Impact of *Lygus* Damage on 1-0 Douglas-fir Seedlings[1]

D. L. Overhulser[2]
P. D. Morgan
R. Miller

Abstract.--Lygus bug feeding on 1-0 Douglas-fir significantly increases cull and the occurrence of forking at harvest. Multiple pesticide applications between July and September can reduce damage by 80-90%.

INTRODUCTION

Since the 1970's, nurserymen in the Willamette Valley have noticed that 2-0 seedlings with multiple tops are associated with deformed terminal growth during the 1-0 year. However, the connection of "bushy-topped" seedlings with the effects of Lygus bug feeding is a recent observation (Shrimpton, 1985; South 1986; and Schowalter, et al., 1986). In western Oregon, Lygus hesperus Knight is now recognized as a common cause of bud abortion and terminal growth deformation in bare root Douglas-fir (D.f.) seedlings. Lygus feeding near the growing tip of 1-0 seedlings results in stem lesions, distorted needles, and deformed tops (Figure 1). Following bud damage, lateral shoots frequently form weak multiple tops (forking) that persist through harvest (Figure 1). Although Lygus bugs are a common problem in agricultural crops, they are an unfamiliar pest to most nursery managers.

Figure l.--Appearance of Ly us damage in 1-0 D.f. seedling (L) and resulting multiple tops in the 2-0 year (R).

[1]Paper presented at the Western Forest Nursery Council Meeting, Olympia, WA, August 12-15, 1986.

[2]Respectively Principal Entomologist and Nursery Manager for the Oregon State Department of Forestry, Salem, OR 97310, and Nursery Technologist for Weyerhaeuser's Aurora Forest Nursery, Aurora, OR 97002.

Lygus bugs (family Miridae) are sucking insects that feed on the growing tips, buds, and flowers of many plants (Figure 2). Agricultural crops such as alfalfa and cover crops like buckwheat and clover can support high Lygus populations. Weed species such as whTtetop, tansy, lambsquarter and Queen Anne's lace are also attrative to Lygus. During feeding, Lygus secrete saliva containing substances that affect the development of plant tissues, often resulting in deformed or aborted growth (Tingey and Pillemer, 1977). Adult Lygus overwinter in and around conifer nurseries. During the early spring adults feed and lay eggs in the stems of agricultural crops or herbaceous weeds. The eggs incubate for 10-14 days before hatching into flightless nymphs which, like adults, feed on plant tissue (Kelton, 1975). Three to four generations are completed per year in western Oregon (Berry, 1978). The adult insects are active fliers and readily move from one crop to another. Damage to nursery seedlings starts in July or August and increases gradually through September. During this period, 1-0 D.f. seedlings typically grow 2.5"-4.3" and produce the succulent growth preferred by this insect.

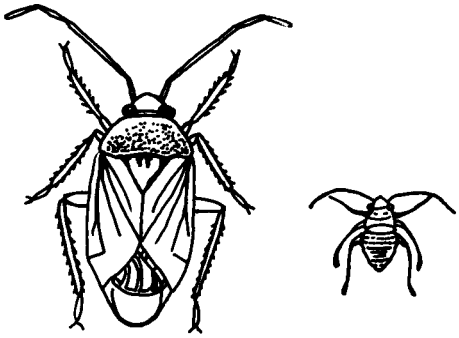

Figure 2.--Adult Lygus bug (L) and nymph (R). Adult bugs are 6-7mm long while nymphs *vary* from 1-6mm in length.

Since 1983, a series of studies on L us impact and damage prevention have been conducted at bare root nurseries. The objectives of the studies included identifying pesticides effective in reducing damage, timing spray applications, and describing the effects of damage on seedling yields and quality.

MATERIALS AND METHODS

Study Areas

In the summer of 1983 a pesticide screening study was conducted in 1D-O D.f. (60 seedlings/ft^2) at Weyerhaeuser's Aurora Nursery near Canby, Oregon. Subsequent work on spray timing and the effects of Lygus damage on seedling yields were conducted at the D. L. Phipps State Forest Nursery at Elkton, Oregon. Seedling densities at the Phipps nursery varied from 17-25/ft^2.

1983 'Pesticide Screening

Insecticides for this study were selected on the basis of registration for nursery crops and use in agriculture for Lygus control. 1D-0 seedlings were sprayed weekly between July 21 and September 26. The following insecticides were evaluated:

Insecticide	Rate (Active Ingredient/Acre)
fenvalerate	0.1 lb
acephate	1.0 lb
endosulfan	1.0 lb

The experimental design for the test was a randomized complete block with each block replicated seven times. Treatment plots were 41 ft. x 150 ft. with a 20 ft. buffer separating adjacent treatments. Lygus damage was measured in twelve one ft^2 subplots located in the center two beds of each treatment plot.

1983 Impact Assessment

Douglas-fir seedling survival was evaluated in conjunction with the pesticide screening study. Numbers of live seedlings present in a one ft^2 plot located in each treatment replication was recorded in the fall.

1984-85 Pesticide Timing Studies

Based on the gradual damage increase shown in earlier work, it was decided the detection of initial damage among 1-0 seedlings was a suitable marker for timing pesticide applications. In both 1984 and 1985, ten subplots (8 inches x 24 inches) located in four untreated plots were used to monitor seedling damage. The following pesticide regimes were tested using fenvalerate at 0.1 lb active ingredient per acre (A.I./A).

Application Timing	Treatments (weeks from initial damage)
1 (check)	–
2	3
3	2, 5
4	2, 5, 7
5	2, 4, 6, 8, 10, 12

The design for the 1984 study was a randomized complete block with each treatment replicated six times. Treatment plots were 38 ft. wide and over 200 ft. in length. Lygus damage was evaluated on the mean of all fifteen 1.5 ft^2 subplots located in the center two beds of each treatment.

During 1984, the effects of Lygus damage before and after 20% of the crop had set bud (September 19) was evaluated on 1-0 D.f. The pesticide used to protect seedlings was fenvalerate at 0.1 lb A.I./Acre. This timing study consisted of the following unreplicated treatments installed in four 34 ft. x 150 ft. plots.

Treatment	Protected Period	Pesticide Timing
1 (check)	-	-
2	Aug.-Oct.	Bi-weekly
3	Aug.-Sept.	Bi-weekly
4	Sept.-Oct.	Bi-weekly

The 1985 pesticide study evaluated an operational recommendation of bi-weekly sprays commencing two weeks after Lygus damage was first detected. Insecticides chosen for this test were fenvalerate (0.1 lb A.I./A) and acephate at 1 lb A.I./Acre. The design for this test was a randomized complete block with each treatment replicated five times. Treatment plots were 38 ft. wide and over 200 ft. in length. Damage assessment was the same as the replicated 1984 pesticide timing study.

1985 Harvest Assessment

The impact of Lygus feeding in the 1-0 year on seedling yields and morphology at harvest was examined using treatment 1 (check) and treatment 5 (6 applications of fenvalerate) from the 1984 pesticide timing study. The three replications evaluated were all located among standard density 2-0 stock (25 seedlings/ft2). Following undercutting, ten 2 ft^2 seedling samples were removed from the center two beds of the treatment areas. The following data were collected from each sample; live trees/ft^2, % acceptable seedlings, % cull seedlings, and % forked seedlings. Seedlings were classified as cull if their caliper was less than 3mm or height less than 20cm.

Statistical Analysis

Lygus damage was evaluated in the fall of the 1-0 year in the replicated pesticide studies. Seedlings were considered damaged if there were any visible signs of Lygus feeding such as distorted needles, stem lesions, deformed buds and forks. Information on tree forking in the unreplicated test was collected during the spring following Lygus damage. Seedling forking was evaluated on ten 1.5 ft^2 subplots within each treatment. Seedlings were considered forked if they lacked a dominant terminal shoot. An x% forking was calculated for each treatment. For the replicated pesticide studies, a x% of Lygus damaged seedlings in each subplot was calculated. Differences between treatments were tested by analysis of variance on arcsine-square-root-transformed percentages. While statistical tests were performed on transformed data, raw data is presented in the tables. Significant differences among several means were tested using Tukey's test (Sokal and Rohlf, 1968). A percentage damage reduction due to pesticide treatments was calculated using the method of Abbott (1925).

RESULTS AND DISCUSSION

Pesticide Tests

Results of the 1983 screening study demonstrated a significant reduction in seedling damage consistent with Lygus feeding being the major cause of seedling deformation (Table 1). All of the pesticides evaluated in 1983 provided an acceptable level of control at this high frequency of application.

Table l.--Percent Lygus damage in 1D-O Douglas-fir seedlings treated with weekly pesticide applications between July 21 - September 26, 1983 at the Aurora Nursery.

Treatment	No. of applications	Seedlings[1] damaged $\bar{X}$(%) 1 plot	Damage reduction (%)
Check	-	14.5 a	-
endosulfan	10	2.4 b	83
acephate	10	2.2 b	85
fenvalerate	10	1.2 b	92

[1]Means not significantly different are followed by the same letter.

When the frequency of application was reduced in 1984, a substantial level of damage reduction was still maintained with as few as two applications of fenvalerate

(Table 2). The 1984 study also indicated that pesticide applications starting two weeks after damage was initially detected provided satisfactory control.

Table 2.--Percent Lygus bug damage to 1-0 Douglas-fir seedlings with different treatment frequencies of fenvalerate (.1 lb A.I./A) at D. L. Phipps Nursery in 1984.

Treatment	No. of applications	Seedlings[1] Damaged $\bar{X}$(%)	Damage reduction (%)
1 (Check)	-	33 c	-
2	1	13 ba	61
3	2	6 ba	82
4	3	6 ba	82
5	6	3 a	91

[1]Means not significantly different are followed by the same letter.

Additional information on pesticide timing resulted from the evaluation of crop protection in relationship to bud set. Seedling protection prior to bud set was critical to reducing the frequency of forked tops (Table 3). Late pesticide application (Sept.-Oct.) did not reduce the frequency of multiple tops.

Table 3.--Effect of pesticide application timing during the 1-0 year (1984) on the occurrence of multiple tops in Douglas-fir seedlings the following spring.

Timing	No. of applications	Forking ($\bar{X}$% ± SE)
Check	-	18.8 ± 2.7
Aug./Oct.	7	4.6 ± 1.5
Aug./Sept.	4	5.9 ± 1.6
Sept./Oct.	3	19.8 ± 2.8

The 1985 pesticide study, showed that four applications, starting two weeks after damage was first detected and continuing on a bi-weekly basis could reduce damage by 80% (Table 4). The timing of the 1985 spray regime in relationship to Lygus damage occurring in check plots is shown in Figure 3. Results from all studies show 80-90% damage reduction with 2-10 pesticide applications.

Another approach to timing pesticide applications for Lygus control used by some nursery managers is to monitor for adults and nymphs on weeds in and around seedling beds.

If 1-0 D.F. seedlings are of a susceptible size (1-1.5" in height) and Lygus is detected on weed species, pesticide treatments are initiated. With this system of spray timing, applications will start earlier than in our studies.

Table 4.--Percent Lygus bug damage in 1-0 Douglas-fir seedlings treated with pesticide at two week intervals between July 17 and September 6, 1985 at the D. L. Phipps Nursery.

Treatment	No. of applications	Seedlings[1] damaged $\bar{X}$(%) 1 plot	Damage reduction (%)
Check	-	61.9 a	-
acephate	4	10.0 b	84
fenvalerate	4	10.6 b	83

[1]Means not significantly different are followed by the same letter.

Since relatively low levels of damage can be achieved with 2-4 pesticide applications, it is possible that much of the damage occurring in untreated areas is produced by the flightless nymphs. Lygus nymphs are easily eliminated with pesticide applications. However, the highly mobile adult Lygus enter and leave nursery beds throughout the summer and are a difficult target for foliar sprays. Spraying in the early morning, when adult Ly us are sluggish, may increase the effectiveness of contact insecticides. Factors rapidly reducing pesticide efficacy on Lygus include heavy irrigation of 1-0 crops and the rapid growth of seedlings.

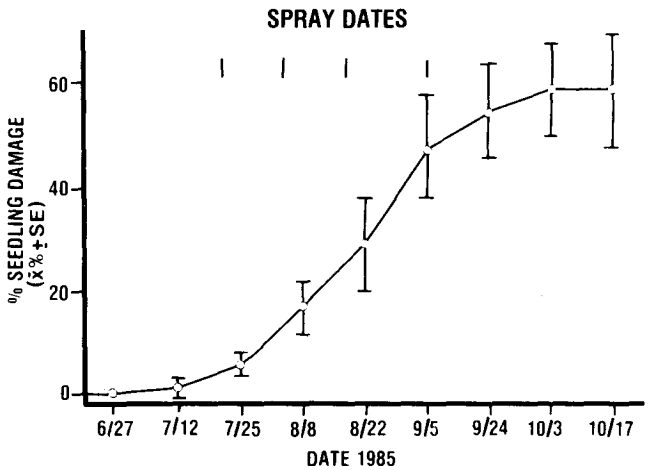

Figure 3.--Mean percent Lygus damage in 1-0 Douglas-fir check plots at the D. L. Phipps nursery in relationship to the 1985 spray schedule.

Lygus Impact

An unexpected result of the 1983 insecticide test was a significant increase in seedling survival in treated plots (Table 5). Increased seedling survival paralleled the trend in damage reduction. A possible explanation for this phenomena might be increased competition and disease in untreated beds. One effect of ~L us damage is increased production of lateral shoots which result in greater shading in high density seedling beds and produce conditions favorable for the foliage disease Botrytis.

Table 5.--Average fall 1-DO seedling density in beds treated with insecticide for control of Lygus damage at the Aurora Nursery in 1983.

Treatment	$\bar{X}$(%) seedlings/ ft2 [1]	Increased survival (%)
Check	53.4 a	-
endosulfan	61.4 b	15
acephate	61.7 b	16
fenvalerate	62.3 b	17

[1]Means not significantly different are followed by the same letter.

The 1985 harvest study showed a significant decrease in cull associated with treated seedlings (Table 6). Many seedlings classified as cull had clear evidence of Lygus damage in the 1-0 year. Reduction of Lygus damage also produced a significant reduction in forked tops. There was no significant difference in the average number of surviving seedlings associated with treatment. Lygus damage occurring in the 2-0 year was not significant enough by itself to produce cull. However, seedlings stunted by Lygus damage in the 1-0 year and attacked again as 2-0 seedlings were sometimes culled for size.

Table 6.--Harvest evaluation of 2-0 Douglas-fir protected from Lygus damage in the 1-0 year (1984) at the D. L. Phipps Nursery.

	$\bar{X}$ Trees/ft2	$\bar{X}$% [1]		
		Acceptable	Cull	Forked
Check	25.8 a	81.2 b	18.8 b	29.1 b
Treated	29.4 a	89.0 a	11.1 a	6.1 a

[1]Means not significantly different are followed by the same letter.

Conclusions

Lygus damage to 1-0 Douglas-fir seedlings can result in significant increases in cull for caliper and size at harvest. Seedlings not protected from ~Ly us feeding have a higher percentage of multi tops. Lygus feeding on 1-0 seedlings prior to the star of bud set is the greatest contributor to multiple tops. At the D. L. Phipps State Forest nursery, pesticide applications start within 2 weeks of initial damage to the 1-0 crop and are repeated at bi-weekly intervals through August. This procedure has reduced L us damage to seedlings by 80-90%.

PUBLICATIONS CITED

Abbott, W.S. 1925. A method of computing the effectiveness of an insecticide. J. Econ, Entomol. 18:265-267.

Berry, Ralph E. 1978. Insects and Mites of Economic Importance in the Northwest. Oregon State University, Corvallis, Oregon. 189 p.

Kelton, L. A. 1975. The Lygus bugs (Genus Lygus Hahn) of North America (Heteroptera; Miridae) Mem. Entomol. Soc. Can. 95. 101 p.

Schowalter, T. D., D. L. Overhulser, A. Kanaskie, J. D. Stein, and J. Sexton. 1986. Lygus hesperus as an agent of apical bud abortion in Douglas-fir nurseries in Western Oregon. New Forests (1:5-15)

Shrimpton, Gwen. 1985. Four insect pests of conifer nurseries in British Columbia. pp. 119-121. IN Proceedings: Western Forest NurseryTouncil-intermountain Nurseryman's Association. USDA Forest Service General Technical Report INT-185.

Sokal, R.R. and F.J. Rohlf. 1969. Biometry. Freeman, San Francisco. 776 pp.

South, David. 1986. The "tarnished plant bug" can cause Loblolly pine seedlings to be "bushy topped". Auburn University Southern Forest Nursery Management Cooperative, Report No. 27.

Tingey, W. M. and E. A. Pillemer. 1977. Lygus bugs: crop resistance and physiological nature of feeding injury. Entomol. Soc. Amer. Bull. 23:277-287.