CHEMICAL[1] CONTROL OF THREE WHITE GRUB SPECIES (COLEOPTERA: SCARABAEIDAE) ATTACKING FRASER FIR CHRISTMAS TREES IN THE SOUTHERN APPALACHIANS

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ABSTRACT

Field experiments were conducted in 1982, 1983, and 1984 to evaluate the efficacy of several insecticides for controlling white grubs infesting Fraser fir, *Abies fraseri* (Pursh) Poir., Christmas trees and pastureland scheduled for fir plantings, and to evaluate insecticide phytotoxicity. The white grub complex consisted primarily of three species: *Pyllophaga anxia* (LeConte) Glasgow, *P. fusca* (Froelich) Glasgow, and *Polyphylla comes* Casey. Mean pretreatment white grub population densities ranged from 20.8 to 77.8 grubs per m^2. Isazophos, diazinon, carbofuran, carbaryl, trichlorfon, chlorpyrifos, and isofenphos demonstrated a wide range of effectiveness in reducing populations while showing no phytotoxicity to grass sod or fir. Isazophos and diazinon applications provided the highest levels of control.

Key Words: White grubs, *Phyllophaga, Polyphylla.*

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INTRODUCTION

White grubs of the genera *Phyllophaga* and *Polyphylla* feed on the roots of a wide variety of grasses, shrubs, and trees, causing extensive root injury before their presence is apparent (Hammond 1940; Luginbill and Painter 1953). Their feeding severs or girdles plant roots, resulting in injury or death (Speers and Schmiege 1961). Adult female beetles often prefer grassland areas for oviposition (Baldwin 1912; Menges 1913; Parks 1918). White grubs have been destructive pests in tree nurseries where seedlings are grown at high densities for transplanting (Heit and Henry 1940; Speers and Schmiege 1961). They feed on the roots of several species of pine, European larch, white spruce, and many other conifers (Stone and Schwardt 1943; Schenefelt and Simkover 1950, 1951; Shenefelt et al. 1954; Fowler and Wilson 1971a, b).

Previous studies by other investigators have demonstrated the effectiveness of organophosphate and carbamate insecticides in reducing grub populations. Insecticide application rates and resultant grub population reductions were similar in several instances. For example, in a laboratory topical toxicity study, diazinon, carbofuran, and trichlorfon elicited high grub mortalities. Chlorinated hydrocarbons and pyrethrin were either ineffective or notably less toxic (Pike et al. 1977).

[1] Use of chemical names in this publication does not imply endorsement of the products named nor criticism of those not mentioned.

Chlordane applied to rangeland had no significant effect on white grub population densities in a field study in Texas (Ueckert 1979). White grub populations in sweet potato fields in Louisiana were significantly reduced after applications of chlorpyrifos, carbofuran, fensulfothion, and ethoprop, whereas chlordane was ineffective (Rolston and Barlow 1980).

Fraser fir, *Abies fraseri* (Pursh) Poir., Christmas trees in plantations in the mountains of North Carolina have recently been injured or killed by white grub infestations consisting of three primary species: *Phyllophaga anxia* (LeConte) Glasgow, *P. fusca* (Froelich) Glasgow, and *Polyphylla comes* Casey. Heavy infestations of grubs were found in Fraser fir plantations and pastureland scheduled for fir plantings. White grub densities had reached destructive levels and control studies were initiated. Objectives of this study were to compare the efficacy of several insecticides in controlling white grubs and evaluate insecticide phytotoxicity to fir trees and grass sod.

MATERIALS AND METHODS

Experimental areas were established at an elevation of 1,333 m on Long Hope Mt., Watauga Co., NC. Four experiments were conducted over three growing seasons.

Porter loam soil (10 - 13% organic matter) was prevalent throughout the test areas. Soil parameters were: pH, 5.4 to 5.5; temperature at a depth of 10 cm, 15 to 17°C; soil moisture by weight, 19 to 22%.

The 1982 experiment was conducted in an established stand of Fraser fir Christmas trees; in 1983 and 1984, experiments were conducted in pastureland scheduled for Fraser fir plantings. Ground cover in all experiments consisted of a mixture of annual and perennial grasses plus various broadleaf weeds which had been mown 2 to 3 weeks before insecticide applications.

In 1982, 1983, and September 1984, each experimental area was divided into 35 plots; the August 1985 experimental area was divided into 25 plots. Plot size in the 1982 experiment was 6 m by 6 m; plots in the 1983 and 1984 experiments were 3 m by 3 m. Experiments were arranged in a completely random design with 5 replications per treatment.

Pretreatment grub densities were estimated by turning back a 0.09 m sample of sod within each plot to expose and count grubs feeding in the rootzone. The soil directly beneath each sample was gently scarified and examined to a depth of 10 cm using a three-pronged, hand-held garden weeder. Grubs and sod were replaced without injury to the grubs. Negligible grub mortality occurred during these procedures. All counts were converted to grubs per m^2. Four weeks after the initial grub survey, posttreatment live grub counts were obtained by sampling a previously undisturbed 0.09 m^2 of sod in each plot and compared to corresponding pretreatment counts to determine population reductions. Reductions in plots receiving the same insecticides were averaged to determine mean percent population decreases attributable to each insecticide.

Liquid insecticides were applied with a hand-pressurized, 9-liter portable sprayer. Granules were applied with a 0.5 m wide hand-pushed spreader, and were not watered in.

In August 1982, liquid insecticides were applied in 7.5 liters of water per 6 m by 6 m plot 7 days after pretreatment grub counts were taken. In August 1983 and August 1984, liquid insecticides were mixed with 2 liters of water per 3 m by 3 m plot and applied the same day that pretreatment grub counts were completed. Granular and liquid formulations were applied the same day.

Insecticides evaluated for efficacy in controlling white grubs in 1982, were carbaryl 20G (20% ai granules) and 80WP (80% ai wettable powder), isazophos 20G, diazinon 4EC (0.48 kg ai/liter emulsifiable concentrate), chlorypyrifos 5EC and isofenphos 5G. The test area was former pastureland planted to a density of 4,080 nine-year-old Fraser fir per ha. Tree rows were sprayed with herbicide (glyphosate, 2.2 kg ai/ha) 4 weeks before insecticide applications. Tractor rows and between-tree rows were not treated with herbicide. Each plot contained 25 Fraser fir trees. In 1983, isazaphos 20G, carbofuran 10G, diazinon 4EC, chlorpyrifos 5EC, carbaryl 80WP, and isofenphos 5G were evaluated and compared.

Isazophos 20G, diazinon 1% ME (0.012 kg ai/liter microemulsion), trichlorfon 80SP (80% ai soluble powder) and carbaryl 20GB (20% ai granular bait) were evaluated in August 1984. Isazophos was also evaluated at three application rates (2.8, 5.6, and 11.2 kg ai/ha) in both 1G and 2EC formulations in September 1984. In all experiments, insecticides were applied from late morning to mid-afternoon in sunny, warm weather.

Phytotoxicity to fir and sod was evaluated during posttreatment counts. Insecticide effects were classified as: 1 = non-phytotoxic — no chlorosis; 2 moderately phytotoxic — needle or grass blade margin burn, or spotting; 3 = severe — extensive chlorosis.

Experimental data were evaluated by analysis of covariance and by contrasting each treatment against its untreated control (Steel and Torrie 1980). Data from the September 1984 experiment were analyzed by contrasting granular versus liquid formulation, as well as by contrasting the two highest application rates (11.2 and 5.6 kg/ha) versus the lowest rate (2.8 kg/ha). The 1982, 1983, and 1984 (Aug) data were also analyzed by Duncan's multiple range test (DMRT, 1982 SAS User's Guide, p. 173).

RESULTS AND DISCUSSION

Mean pretreatment grub population densities (± standard error) during 1982, 1983, 1984-August and -September experiments were 77.8 ± 5.7, 62.7 ± 1.9, 26.5 ± 2.6, and 20.8 ± 3.4 grubs/m^2, respectively. The highest count of 174 grubs/m^2 was sampled in 1982, with maximal counts of 130, 76 and 76 grubs/m^2 sampled in 1983 and 1984-August and -September, respectively. Ten grubs per m^2 is considered to be the economic damage threshold in grass sod (Short and Reinert 1977). This density is also considered to be the economic damage threshold in Christmas tree plantings.

The insecticides exhibited a wide range of effectiveness in reducing grub populations within the sod thatch and rootzone areas (Table 1). Population reductions were observed for all grub instars with no apparent differences between early, middle, and late periods of grub development. Throughout the experimental periods, isazophos and diazinon caused the highest population reductions, while significant differences from other treatments varied. Carbofuran caused a high population reduction in the 1983 experiment. In 1982, none of the insecticides reduced grub populations below the damage threshold, and in 1983 only isazophos

Table .1 Population reductions of three white grub species attacking Fraser fir Christmas trees, as a function of insecticide treatments.

Yr	Treatment	Rate, kg ai/ha (lb ai/acre)	$\bar{x}$ ± SE pretrt grub pops grubs/0.09m[2]	$\bar{x}$ ± SE posttrt grub pops* grubs/0.09m[2]	% pop reduc	Sig level
1982	isazophos 20G	11.2 (10.0)	6.2 ± 1.6	3.2 ± 1.6 a	48	0.0537
	diazinon 4EC	3.4 (3.0)	9.6 ± 2.2	4.2 ± 1.0 a	56	0.1103
	carbaryl 20G	11.2 (10.0)	5.6 ± 0.4	3.8 ± 0.8 a	32	0.1325
	carbaryl 80WP	4.9 (4.4)	7.4 ± 0.4	4.2 ± 0.4 a	43	0.1525
	chlorpyrifos 5EC	0.3 (0.3)	6.0 ± 1.2	5.0 ± 0.5 a	17	0.4314
	isofenphos 5G	2.3 (2.0)	6.0 ± 1.3	6.2 ± 1.7 a	-3	0.9989
	control		7.4 ± 2.0	6.4 ± 0.2 a	14	
1983	isazophos 20G	11.2 (10.0)	5.8 ± 1.1	0.6 ± 0.4 a	90	0.0022
	carbofuran 10G	11.2 (10.0)	5.0 ± 1.9	1.0 ± 0.4 a	80	0.0057
	diazinon 4EC	6.8 (6.0)	5.8 ± 1.6	1.6 ± 0.8 a	72	0.0159
	chlorpyrifos 5EC	0.6 (0.5)	5.4 ± 1.0	1.8 ± 0.5 a	67	0.0243
	carbaryl 80WP	24.8 (22.0)	6.0 ± 1.0	2.2 ± 1.1 ab	63	0.0454
	isofenphos 5G	4.6 (4.0)	6.2 ± 0.8	3.2 ± 1.1 ab	48	0.2056
	control		6.2 ± 1.5	4.8 ± 1.1 b	23	
1984	diazinon 1%ME†	5.6 (5.0)	2.6 ± 0.9	0.2 ± 0.2 a	92	0.0036
(Aug)	isazophos 20G	11.2 (10.0)	2.2 ± 0.5	0.2 ± 0.2 a	91	0.0057
	trichlorfon 80SP	11.2 (10.0)	1.6 ± 0.5	0.8 ± 0.4 ab	50	0.1173
	carbaryl 20GB‡	11.2 (10.0)	2.6 ± 0.5	1.4 ± 0.5 bc	46	0.3359
	control		3.0 ± 1.2	2.0 ± 0.5 c	33	
1984	isazophos 1G	11.2 (10.0)	2.4 ± 0.9	0.0 ± 0.0 d	100	0.0001
(Sep)	isazophos 2EC	11.2 (10.0)	2.4 ± 1.3	0.0 ± 0.0 d	100	0.0001
	isazophos 1G	5.6 (5.0)	1.2 ± 0.6	0.0 ± 0.0 d	100	0.0001
	isazophos 2EC	5.6 (5.0)	1.2 ± 0.4	0.0 ± 0.0 d	100	0.0001
	isazophos 1G	2.8 (2.5)	3.2 ± 2.2	1.4 ± 0.3 e	56	0.3730
	isazophos 2EC	2.8 (2.5)	2.0 ± 1.5	1.4 ± 0.2 e	30	0.1546
	control		1.2 ± 0.5	1.4 ± 0.2 e	-17	
	granular vs emulsifiable concentrate formulation					0.8027
	11.2 & 5.6 kg/ha 2.8 kg/ha rate					0.0001

* Means sharing the same letter do not significantly differ, P = 0.05 (letters a, b, & c — DMRT, 1982 SAS User's Guide; letters d & e — Contrast analysis).

† Microemulsion, 1% ai by weight.

‡ Granular bait.

20G reduced grub populations below this level. In 1984 tests, several insecticides reduced grub population densities below the damage threshold; however, pre-treatment and untreated control densities were lower than in previous years. Phytotoxicity to fir trees and sod was not observed during the experiments. At applied rates, all insecticides were graded as class 1: non-phytotoxic — no chlorosis.

In the second 1984 experiment, both granular and emulsifiable concentrate formulations of isazophos caused similar results at the two higher rates of application; these formulations did not differ significantly in their effectiveness. The effect of the lower application rate was not significantly different from that of the control, and was significantly different from that of the two higher application rates (P = 0.05).

Timing of insecticide applications is an important consideration in controlling grubs. Different beetle species in a grub complex may arrive in the root feeding zone near the soil surface at varying times during the growing season. Thus, grub population densities should be monitored to insure insecticides are applied prior to the time grubs reach damaging densities in the root feeding zone (Kard and Hain, unpublished data). If densities reach 10 grubs per m^2, insecticide treatments should be initiated. Also, if populations consist mainly of large, late-stage grubs, it may be appropriate to treat earlier in the season as these grubs tend to feed in the spring and then dig down into the soil to pupate (Hammond 1940; Speers and Schmiege 1961). Insecticides may not penetrate to pupae deep in the soil, and pupal sensitivity to insecticides may differ from that of grubs.

Insecticides which were tested may be useful for control of white grubs while exhibiting no phytotoxicity to Fraser fir or grass sod when applied at the rates used here. However, adult beetles are strong fliers and possibly could repopulate a previously treated area in a few seasons. For example, if an initial population was only 1 grub per 0.09 m^2, and 90% were killed by an insecticide treatment, approximately 11,000 grubs per ha would survive to adults. Thus, multiple insecticide treatments and other supplemental control methods may need to be integrated into the overall control plan.

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