Paclobutrazol use on loblolly pine (Pinus taeda L.)

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Abstract

Paclobutrazol was applied at several rates as a foliar spray to nursery grown loblolly pine seedlings. Paclobutrazol significantly reduced ($P<0.05$) seedling height without reducing root collar diameter. Seedling heights were reduced by up to 20% depending on rate of paclobutrazol applied. Shorter seedlings may be more tolerant to desiccating environments and drought. Paclobutrazol was applied as a foliar dip to nursery run (1-0) loblolly pine seedlings at the rates of 500, 250, 125, 62.5, 31.25, and 0 ppm. Paclobutrazol at the rate of 125 ppm significantly increased ($P<0.05$) root growth potential (RGP). Compared to the control, total number of new roots was increased by 88% without reducing shoot growth. Increasing loblolly pine root growth with paclobutrazol may be important for improving plantation establishment, especially on harsh sites.

Introduction

Paclobutrazol (2RS,3RS)-1-(4-chloropheny1)-4,4-dimethy1-2-(1H-1,2,4 triazol-l-yl)pental-3-ol is a broad spectrum xylem-mobile plant growth regulator which can reduce woody plant growth by inhibiting gibberellin biosynthesis. Paclobutrazol reduced shoot growth in cherry (Prunus avium L.) (Asamoah and Atkinson, 1985), apple (Malus pumila Mill.), pear (Pyrus communis L.) (Williams and Edgerton, 1983), pecan (Carya illinoensis (Wangenh.) (Wood, 1984), Douglas fir (Pseudotosuga menziessii Mirb.), and loblolly pine (Pinus taeda L.) (Wheeler, 1987). Asamoah and Atkinson (1985) found that paclobutrazol not only reduced cherry shoot growth but also increased the root to leaf dry

weight ratio in apple seedlings.

Seedling root/shoot ratio can influence loblolly pine survival (Larsen et al. 1986). Seedling shoot growth should be managed in the nursery so that transpiration does not exceed water uptake after outplanting, especially when seedlings are planted in cold soil or under dry conditions with high winds (Larsen et. al. 1986). Application of paclobutrazol significantly increased the root/shoot ratio of container grown loblolly pine by reducing root growth less than shoot growth (Wheller, 1987). Further study was recommended to clarify the effects of paclobutrazol on loblolly pine.

Paclobutrazol can increase the fine roots of apple (Steffens and Wang 1984) and loblolly pine (Wheller 1987). Root growth potential (RGP), a seedlings ability to produce new roots after outplanting is correlated to seedling survival (Feret and Kreh 1985, Larsen et. al. 1986). A number of cultural practices have been used to enhance RGP including time of lifting, undercutting, root wrenching, fertilization, and cold storage (Ritchie and Dunlap 1980). Research was undertaken to determine if paclobutrazol has the desirable effect of increasing seedling root growth.

Materials and Methods

Experiment 1

Loblolly pine seed was machine sown on April 15th at the Virginia Division of Forestry's New Kent nursery. Paclobutrazol was applied to seedlings as a single application, or as four separate applications. The single application was made on May 23rd, 1988 at the rates of 3000, 2000, 1000, 500, 250, 125, and 0 ppm paclobutrazol. Four applications at the rates of 750, 500, 250, 125, 62.5, and 31.25 ppm were made at 3 week intervals beginning on May 23, 1988. In all cases paclobutrazol was applied in the form of Bonzi [a]s a foliar spray until runoff. The study used a randomized complete block design with four blocks. Each treatment consisted of 0.36 m^2 of nursery bed.

The seedlings were hand dug on February 21, 1989 and 2 subset of 10 randomly selected seedlings each were taken per treatment. In the first subset root collar diameter, stem height, and number of lateral roots were measured. Seedlings were dried for 72 hours at 60°C and needle, stem, lateral root, and taproot biomass were measured.

The second subset was stored at 2°C until February 24th

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and then planted to determine RGP following the methods of Feret and Kreh (1985). A two-way ANOVA model was used for partitioning variance with paclobutrazol concentration and blocks as the main effects. Duncan's New Multiple Range Test was used for mean separation when an F-statistic was significant ($P<0.05$).

Experiment 2

Nursery run loblolly pine (1-0) seedlings were machine lifted on February 2nd and stored at 2°C until February 4th. Seedlings were then treated with paclobutrazol in the form of Bonzi™ at the rates of 500, 250, 125, 62.5, 31.25, and 0 ppm (control). Paclobutrazol was applied by totally immersing the seedling shoot to the root collar for 10 seconds. Three seedlings per rate of paclobutrazol were planted in a 12 cm pot containing ProMix BX . Each rate was replicated 10 times and arranged in a randomized complete block design. The seedlings were grown under a 16h photoperiod and watered daily. After 21 days seedlings were excavated and new root growth was measured as in Experiment 1. A two-way ANOVA model was calculated with paclobutrazol concentration and blocks as the main effects. Duncan's New Multiple Range Test was used for mean separation when the F-statistic was significant ($P<0.05$).

Results and Discussion

Experiment 1

Paclobutrazol significantly ($P<0.05$) reduced seedling height and stem biomass of nursery grown loblolly pine (Table 1). Four applications of paclobutrazol at lower rates resulted in greater and more consistent reductions in height growth compared to a single application at a high rate. Although stem biomass was significantly reduced there was no significant reduction in root collar diameter or needle biomass (Table 1). Reductions in root biomass were not significant and generally were equal in proportion to reductions in shoot biomass thus, the root/shoot ratio was not altered (Table 1). Therefore, paclobutrazol produced shorter seedlings without reducing needles needed for photosynthesis or roots needed for water uptake. Shorter seedlings due to application of paclobutrazol may be more tolerant to desiccating environments and drought (Larsen et al. 1986).

The use of paclobutrazol as a foliar spray on loblolly pine seedbeds resulted in the chemical coming in contact with the soil. Because paclobutrazol is very persistent in the soil (Wheeler, 1987) this type of application may not suitable for use in bareroot nurseries. This problem could possibly be resolved by using a wick applicator to apply the

growth regulator directly to seedling foliage. Wick applicators could be adjusted to apply paclobutrazol to the foliage of taller seedlings only, allowing shorter seedlings to continue to develop at a normal rate.

Experiment 2

There were significant differences among rates of paclobutrazol for number of short roots, number of long roots, total number of roots, and total RGP of loblolly pine (Table 2). There was no significant difference in shoot growth among rates (Table 2). Compared to the control, paclobutrazol at the rate of 125 ppm increased number of short, number of long, and total number of new roots by 75%, 136%, and 88% respectively.

Increasing loblolly pine root growth with a foliar dip in paclobutrazol, without a concomitant reduction in shoot growth, may prove to be of great importance for plantation establishment. RGP has been positively correlated with seedling survival and growth, therefore nursery managers have strived to produce seedlings with high RGP. A pre-planting treatment of loblolly pine with paclobutrazol could be used to augment inherent RGP. This would be particularly important on harsh planting sites. The application of paclobutrazol to pine seedlings at low rates in the field would be a simple practice and should not preclude its use by planting crews.

A possible alternative to a pre-planting treatment in the field may be a post-lifting treatment after seedling grading and bundling. This would be similar to the practice of dipping loblolly pine roots in clay. If RGP can be enhanced by a pre-storage treatment the need to apply paclobutrazol in the field would be eliminated.

Further study is needed to clarify if root growth of other species can be increased by paclobutrazol. Field trials should be conducted to determine how paclobutrazol induced root growth affects survival and growth after outplanting.

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Table 1. Effects of paclobutrazol on nursery grown (1-0) loblolly pine seedling height, biomass, and root/shoot ratio.

Rate (ppm)	Seedling Height	Stem Biomass	Needle Biomass	Root Biomass	Root Collar Diameter	Root/ Shoot Ratio
	..cm..	.....grams.....			.mm.	
0	28.8a[1]	1.68a	3.78a	1.45a	5.3a	.25a
125 x 1	28.3abc	1.47a	3.36a	1.31a	5.1a	.26a
250 x 1	27.8abcd	1.54ab	3.50a	1.39a	5.2a	.26a
500 x 1	28.7ab	1.41abcd	3.37a	1.37a	5.0a	.27a
1000 x 1	25.3 bcde	1.28 bcde	3.07a	1.25a	4.7a	.26a
2000 x 1	23.7 de	1.06 de	3.00a	1.10a	4.7a	.26a
3000 x 1	25.8abcde	1.21 bcde	3.24a	1.18a	4.8a	.25a
31.2 x 4	24.9 cde	1.17 bcde	3.05a	1.12a	4.8a	.25a
62.5 x 4	26.1abcde	1.26 bcde	3.48a	1.24a	4.9a	.24a
125 x 4	24.8 cde	1.16 cde	3.28a	1.23a	4.9a	.27a
250 x 4	24.4 de	1.04 de	3.15a	1.10a	4.6a	.24a
500 x 4	23.0 e	1.14 de	3.49a	1.22a	4.9a	.25a
750 x 4	23.0 e	.99 e	3.04a	1.07a	4.6a	.26a

[1] Values in the same column with the same letter were not significantly different at the 0.05 level of probability using Duncan's New Multiple Range Test.

Table 2. The effects of rate of paclobutrazol on the root growth potential and shoot growth of nursery run (1-0) loblolly pine.

Rate (ppm)	Short Roots	Long Roots	Total Roots	Shoot Growth
	.....number.....			..cm..
500	28.4ab[1]	4.9 b	33.4ab	1.8a
250	25.3abc	4.7 b	30.0abc	1.8a
125	32.4a	9.2a	41.6a	1.8a
62.5	16.6 bc	3.6 b	20.5 bc	1.7a
31.25	13.3 c	2.6 b	15.9 c	1.6a
0	18.5 bc	3.9 b	22.1 bc	1.5a

[1] Values in the same column with the same letter were not significantly different at the 0.05 level of probability using Duncan's New Multiple Range Test.

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