Plant Growth Regulators

EFFECTS OF PLANT GROWTH REGULATORS ON LOBLOLLY PINE SEEDLING DEVELOPMENT AND FIELD PERFORMANCE

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ABSTRACT -- Four plant growth regulators (ancymidol, benzyladenine, ethrel, and flurprimidol) were compared with two top pruning treatments at a nursery near Byron, Georgia. Chemical applications in August were generally more effective in reducing growth than September applications. Among the growth regulators tested, only benzyladenine applied in August appeared to reduced height growth by 2.3 cm. A single top pruning in early August substantially increased average height growth to the point where average seedling heights in December were not reduced. The treatments were lifted in January and deep-planted in mid-March on an old-field near Auburn, AL. First year survival was excellent (> 92%) despite the dry spring. None of the treatments were significantly different from the control in terms of survival or height growth in the field.

Introduction

Under favorable growing conditions, loblolly pine (Pinus taeda L.) seedlings in bare-root nurseries often initiate a rapid phase of height growth during August which usually terminates in late September as photoperiod decreases. Controlling this phase of height growth can be an important factor in culturing seedlings for planting on reforestation sites in the southern region. Tall loblolly pine seedlings (> 25 cm) are often considered undesirable for tree planting (Tuttle et al. 1987, 1988). Not only do tall seedlings impede hand planting operations, but they may also suffer more from exposure to desiccating environments and drought (Dierauf 1976; Carlson and Miller 1988).

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Current methods for reducing seedling heights include top pruning (Dierauf 1976), root pruning (Tanaka et al. 1976; Miller et al. 1985), and withholding irrigation (Stransky and Wilson 1964; Hennessey and Dougherty 1984). To be effective, top pruning requires removal of a significant portion of existing shoot followed by several repeated cuttings to prevent new shoot initiation from axial buds from exceeding the original growth. Root pruning or wrenching during July and August has obtained wide spread acceptance, but it appears to be more easily applied in sandy soils. Although inducing moisture stress by withholding irrigation can be effective, it is not always feasible due to high rainfall patterns in the southern coastal region.

Plant growth regulators are widely used in ornamental plant production to control the development of plant size, leaf shedding, growth cessation and other characteristics

(Geissbuehler et al. 1987). Growth regulators can be a cost-effective approach in creating a uniform crop appearance for marketing purposes and creating other characteristics which are desireable for handling and shipping. Such compounds have been tested on conifers for controlling growth in ornamental landscapes (Backhaus et al. 1976), seed orchards (Hare 1982, 1984), nursery seedlings (Plank 1939; Maki et al. 1946; Weston et al. 1980; Wheeler 1987), and christmas trees (Little 1984). Many of these chemicals have been reported to reduce growth, but with resulting detrimental effects either in terms of appearance or subsequent growth (Ross et al. 1983). Additionally, chemicals like paclobutrazol (Wheeler 1987), while they are highly effective in controlling heights, are very persistent in the soil. This characteristic limits their usefulness in bare-root nurseries. The objective of the study was to determine if selected growth regulator treatments could reduce late summer height growth in loblolly pine seedlings, and would these treatments adversely affect subsequent field performance.

Methods

The experiment was installed on July 28, 1987, using unimproved loblolly pine at the Georgia Forestry Commission Nursery near Byron, GA. The study was laid out as a randomized complete block design with four blocks. Treatments included four chemicals (Table 1) which were applied at one of two application times (early August or early September). Plots were one meter long by 1.4 meters wide with a 0.5 meter buffer strip between plots. Within each plot eighteen were selected for repeated height measurements. Three seedlings from each of the center six drill rows nearest a line placed across the plot were tagged with numbered water-proof tape. Initial heights were measured on these seedlings at the time of treatment and every month thereafter until December.

Each chemical treatment within a monthly period was applied twice in two separate broadcast spray applications, 7 to 9 days apart. The early August applications were made on July 28th and August 8th. The September applications were made on the 4th and 11th. The solution was applied through 3-LP8003 flat fan nozzles at a pressure of 1330 kPa and a volume of 230 l/ha. Seedlings within the top pruning treatment were clipped to a uniform height of 15 cm in late July for the August treatment and 20 cm in early September for the September treatment. Approximately 70% of the seedlings in the top pruning treatment were clipped in late-July and 40% during the early September top pruning.

The ancymidol, benzyladenine, top pruning and the control treatments were lifted for outplanting and size measurements on January 6, 1988. The diameter, shoot and root dry weights were measured on the tagged seedlings. Another twenty-five seedlings per plot were placed in plastic bags and stored between 3 to 5oC until mid-March. The planting site was situated 10 km north of Auburn, AL on an abandoned agricultural field dominated by broomsedge. The surface soil texture is a clay loam. The seedlings were deep-planted (the root-collar was placed approximately 9 cm below ground-level) with shovels. Survival and height growth of each treatment was evaluated in November, 1988 and again in April, 1990. The data was subject to an analysis of variance and when appropriate, means were compared using Duncan's New Multiple Range Test (Steel and Torrie 1960).

Results

Total heights at the end of the season were similar among all treatments (Table 2). The extreme

variability in seedling development both within plots and between blocks likely obscured treatment effects. Differences in height growth were easier to detect than differences among final heights.

Of the treatments applied in August, only the high rate of benzyladenine significantly reduced height growth during August (Table 2). None of the treatments reduced growth during September when compared with the control. However, when applied in August, the top pruning, ancymidol, and ethrel treatments resulted in increased growth during the month of September. Chemicals applied in early September were generally ineffective in reducing subsequent height growth. The single top pruning applied in August increased average height growth during September. In contrast, seedlings top pruned in early September did not grow more than the controls. In general, height growth for all treatments was largely completed by the end of September.

No significant treatment effects were associated with either shoot length (Table 2) or diameter (Table 3). However, the height/diameter ratio was reduced by the August applications of benzyladenine. Similarly, root and shoot dry weights were unaffected by any of the treatments compared with the control (Table 3). None of the treatments improved the shoot/root ratio.

Survival among treatments (Table 4) was very high despite the 10 week storage period and the lack of rainfall for several weeks following planting. The high survival was due in part to planting the seedlings 8.8 cm deeper than the level at which they were grown in the nursery. Height growth among treatments in the field was very similar. We observed no visible evidence that the abnormal shoot growth effects (multiple buds and shorter needles) from benzyladenine persisted after planting when seedling evaluations were made in the fall of 1988.

Discussion

The results from the single top pruning are consistent with previous research on this practice (Barnett 1984; Dierauf 1976; Dierauf and Olinger 1982; Mexal and Fisher 1984; Duryea 1990). A single, early top pruning tends to stimulate height growth in the nursery. As a result, removal of a significant portion of the shoot and repeated prunings are needed to reduce total height. A loss in growth from the taller seedlings that were pruned resulted in a more uniform crop. When conditions for survival are less than optimum, there appears to be a net benefit in terms of field survival (Dierauf 1976; Dierauf and Olinger 1982).

It appears that certain chemical growth regulators may be effective in controlling height growth in southern pine nurseries. In this preliminary study, benzyladenine was effective in reducing height growth when applied in August. We observed no detrimental effects on subsequent seedling performance from the 11.5 l/ha rate. However, at higher rates, benzyladenine can produce undesirable effects such as abnormal bud development, inhibition of secondary needle extension, delayed bud break, and reduced root development (data not shown). Consequently, the rate and timing of application must be carefully controlled in order to achieved a net beneficial effect. Low to moderate rates of benzyladenine (up to 11.5 l/ha) applied after secondary needle elongation is nearly complete is worthy of further study. It may also be desirable to combined this treatment with top pruning.

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Table 1. Chemical treatments and rates used. Two applications were made to each plot to equal the total amount applied.

Common name	Concentration		Rate/application		Total applied	
(Product Trade Name)	Low	High	Low	High	Low	High
	mg a.i./liter		g a.i./ha		Product/ha	
Flurprimidol (Cutlass 50W)	0.5	1.0	0.115	0.23	0.46 g	1.84 g
Ancymidol (A-Rest 0.0264%)	50.0	100.0	11.5	23.0	87.4 l	174.8 l
Ethrel (Florel 4%)	1000.0	2000.0	230.0	460.0	11.5 l	23.0 l
Benzyladenine (Pro-Shear 2%)	500.0	1000.0	115.0	230.0	11.5 l	23.0 l

Each solution contained 0.05% of ARMOX C-12 wetting agent.

Table 2. Height growth during August and September and the final height in December for tagged seedlings of each treatment.

	Product		Height growth		December
Treatment	rate/ha	Date	August	September	height
		month	---------- mm ----------		
Control			38.1 a	12.7 def	214
Top prune	-----	August	23.0 ab	48.8 a	219
Top prune	-----	September	----	12.0 ef	209
Ancymidol	87.4 l	August	38.2 a	19.5 bcde	231
Ancymidol	87.4 l	September	----	16.3 cdef	229
Ancymidol	174.8 l	August	38.4 a	26.3 bc	241
Ancymidol	174.8 l	September	----	19.5 bcd	222
Benzyladenine	11.5 l	August	22.0 ab	15.6 cdef	211
Benzyladenine	11.5 l	September	----	21.5 bcde	211
Benzyladenine	23.0 l	August	18.1 b	0.7 f	191
Benzyladenine	23.0 l	September	----	15.7 cdef	213
Etherl	11.5 l	August	33.6 ab	25.4 bcd	222
Etherl	11.5 l	September	----	17.8 cdef	223
Etherl	23.0 l	August	28.6 ab	30.7 b	208
Etherl	23.0 l	September	----	21.1 bcde	213
Flurprimidol	0.92 g	August	37.9 a	14.1 cdef	225
Flurprimidol	0.92 g	September	----	18.0 bcdef	217
Flurprimidol	1.84 g	August	29.0 ab	21.8 bcde	224
Flurprimidol	1.84 g	September	----	23.9 bcde	229

No significant treatment effects were found for height in December (F-test = 0.5840). Means followed by the same letter are not significantly different at the 5% level of probability (as determined by Duncan's New Multiple Range test).

Table 3. Average diameter, height/diameter ratio, shoot weight, root weight, and shoot/root ratio for tagged seedlings lifted on January 6, 1988.

				Height	Dry weight		Shoot
Treatment	Rate	Date	Diameter	diameter	Shoot	Root	Root
	l/ha	month	- mm -	- mm/mm -	---- g ----		- g/g -
Control			4.05	53 a	2.61	1.33	1.94 c
Top prune	-----	August	4.10	54 a	2.54	1.12	2.27 abc
Top prune	-----	September	4.19	50 ab	2.61	1.37	1.95 c
Ancymidol	87.4	August	4.69	49 ab	3.68	1.61	2.29 abc
Ancymidol	87.4	September	4.39	52 a	3.06	1.28	2.39 ab
Ancymidol	174.8	August	4.48	54 a	3.25	1.37	2.36 ab
Ancymidol	174.8	September	4.36	50 ab	3.15	1.39	2.25 abc
Benzyladenine	11.5	August	4.58	46 b	3.24	1.51	2.16 abc
Benzyladenine	11.5	September	4.12	53 a	2.82	1.09	2.53 a
Benzyladenine	23.0	August	4.28	45 b	2.57	1.27	2.01 bc
Benzyladenine	23.0	September	3.95	53 a	2.90	1.41	2.02 bc

No significant treatment effects were found for diameter (F-test = 0.1987), shoot weight (F-test = 0.1681) or root weight (F-test = 0.1925). Means followed by the same letter are not significantly different at the 5% level of probability (as determined by Duncan's New Multiple Range test).

Table 4. Initial post-planting heights, height growth and survival for seedlings that were planted in mid-March, 1988. Growth and survival were evaluated in April, 1990.

Treatment	Rate	Date	Initial Height	Height Growth	Survival
	l/ha	month	---------- cm ----------		-- % --
Control			12.6	108	95
Top prune	-----	August	14.6	98	89
Top prune	-----	September	14.3	106	98
Ancymidol	87.4	August	15.8	105	93
Ancymidol	87.4	September	15.1	105	94
Ancymidol	174.8	August	16.4	107	94
Ancymidol	174.8	September	14.9	107	93
Benzyladenine	11.5	August	13.7	108	95
Benzyladenine	11.5	September	14.3	106	95
Benzyladenine	23.0	August	11.8	107	93
Benzyladenine	23.0	September	12.7	101	93

No significant treatment effects were found for initial height (F-test = 0.0788), growth (F-test = 0.6545) or survival (F-test = 0.6873).

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