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Shoot Apex Development and Rooting of *Pinus strobus* L. by Dwarf Shoots[1]

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Abstract. **Foliar applications of benzyladenine (BA) increased bud development of dwarf shoots of *Pinus strobus* L. When compared to dikegulac-sodium (Atrinal), pyranybenzyladenine (PBA), gibberellic acid (GA_3), or pinching. Differences in rate of application of BA were not significant. Vegetative propagation of dwarf shoots varied between individual clones and between years.**

Vegetative propagation of *Pinus* by grafting and stem cuttings has been investigated by numerous horticulturists and foresters. These methods are commercially unacceptable because of stock-scion incompatibility, expense, limited propagules available from desired trees, and low rooting percentages. Use of dwarf shoots has been suggested as a method for reproducing pines. Investigators have reported rooting dwarf shoots of various species of both hardwood and softwood pines (5, 6, 7, 8, 9, 10). Although this method has shown promise, most plants have died after rooting due to the inability of the bud to develop into a growing shoot.

Early studies by Masters (9) showed pruning of terminal buds from long shoots could stimulate bud development of intact dwarf shoots. These buds elongated and formed new shoots. Kummerow and Hoffman (3) reported that dwarf shoots treated with kinetin (50-100 ppm) formed growing shoots in *Pinus radiata* D. Don. Concha and Montaldi (2) reported an increase in bud development when *Pinus elliottii* Engelm. was treated with BA at 100 ppm for 20 days. Cohen and Shanks (1) showed that BA could stimulate bud development in dwarf shoots of *Pinus ponderosa.*

The objectives of this study were: 1) to evaluate growth regulators (BA, GA_3, PBA, dikegulac-sodium) and pinching as a method to enhance the availability of developed buds in dwarf shoots for use in the propagation of *Pinus strobus,* and 2) to investigate the variability of rooting as influenced by clonal differences.

Materials and Methods

Expt. 1A. Three-year-old *Pinus strobus* were root-pruned and placed in 3.8 liter containers consisting of 3 bark: 1 sand: 1 peat. On March 8, 1975, all plants were transferred to the greenhouse and given about 11 hr of natural light followed by a continuous 3 hr of 1080 lux of incandescent light. From March through May, plants received ample water and fertilizer to stimulate new shoot development.

On June 20, as the sheath of the dwarf shoots began to shed, plants were selected for uniform terminal stem length. Each terminal stem was tagged and plants were arranged in a randomized complete block design with 3 replications and 3 plants per replicate.

Growth regulator treatments (BA, PBA, GA_3, and dikegulac-sodium) were applied to the foliage on June 20 with a compressed air stainless steel sprayer applying 50 ml of chemical per plant. Cultural treatments consisted of pinching and no pinching. Chemical applications were made in the morning when temp ranged between 19-22°C.

Buds measuring greater than 2 mm in length were used as a criteria for estimating the number of new shoots apices. Number of buds developed within the dwarf shoot on the terminal stem were recorded 8 weeks following treatment.

Expt. 1B. Six-year-old field grown *Pinus strobus* plants were selected in late May, 1976. Dwarf shoots on terminal stems were tagged and allowed to shed their sheath as in 1975.

Following this, plants were treated on June 30 with either BA or GA_3. Application method, rate per plant, no. of plants per replicate, and criteria for measuring bud development were the same as previously noted.

Expt. 2. Field-grown *Pinus strobus* plants (5 to 7-years-old) were selected for uniform stem and needle growth in June, 1975. During both years, trees were pruned to stimulate bud development within the dwarf shoot. From each tree in 1975 and 1976, 60 dwarf shoots were removed from the uppermost terminal whorl on Jan. 15.

Samples were placed in plastic bags and submerged in water overnight to prevent desiccation. Each plant was replicated 3 times with 20 samples used per replication.

On Jan. 16, dwarf shoots were dipped in 0.8% Hormodin talc and placed in a perlite medium under intermittent mist. A plastic tent was utilized to cover the mist bed to retain high humidity. Temp in the propagation structure ranged from 23-39°C (day) and 16-20° (night). Dwarf shoots were evaluated after 120 days for % rooting.

Results

BA was the only effective treatment to increase the number of developed buds within dwarf shoots in the 2 year growth regulator study (Table 1). Differences in rate of application of BA were not significant during either year.

Plants treated with BA, typically responded within 4 weeks after application. Bud development in the dwarf shoots was usually confined to the upper portion of the stem, but by 8 weeks following treatment, the entire length of the stem produced buds within the dwarf shoots. Following this, bud growth on several dwarf shoots did elongate forming lateral shoots. Visual injury related to BA treated plants did show chlorosis of the foliage. Injury was more severe at the higher concn of BA.

Pinching of terminal buds of long shoots did stimulate some bud development within dwarf shoots. Bud growth was visible after 4 weeks, but was restricted to the upper 1 cm of the terminal stem.

Treatments of dikegulac-sodium, GA_3, and PBA were least effective in stimulating bud development. No visual injury was noted with any of these chemicals.

Rooting of dwarf shoots was dependent on individual clones and that variability existed among clones between years even

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Table 1. Effect of pinching, BA, PBA, dikegulac-sodium, and GA_3 on no. of buds developed within dwarf shoots of *Pinus strobus* after 8 (1975) and 15 (1976) weeks.

Treatment	Concn (ppm)	Mean no. of buds formed within dwarf shoots on terminal stems[z] 1975	1976
PBA	100	0	–
	200	1	–
BA	500	37	39
	1000	48	43
GA_3	100	–	0
	200	–	0
Dikegulac-sodium	1000	0	–
	3000	0	–
Manual Pinch		7	6
Control		0	0
LSD 5%		12	4

[z]Each value is the mean of 3 replications. Terminal stem length = 4 cm.

though these trees were the same age and treated in the same manner. Rooting from 25% to 68% in 1975; 7% to 68% in 1976. During the winter of 1976, foliage of dwarf shoots of certan clones was chlorotic and many samples rotted within 30 days after being placed in the propagation bed.

During both years a similar sequences of morophological changes occurred in the development of roots and shoots of *Pinus strobus*. Initially, the buds of dwarf shoots began elongating after 3 weeks under intemittent mist. These new shoots, after 120 days, average 0.5-1.0 cm in length and needles were shorter than normal. Terminal buds were visible on these new shoots about 3 months after sticking cuttings.

The first observations of rooting were noted between the 45th and 60th day, but the majority of the dwarf shoots rooted between 90-120 days after being placed in the propagation facility. Dwarf shoots had 1 root which were characteristically brown, brittle, and contained a fleshy root tip. After potting, lateral roots were initiated from the primary root and further shoot elongation occurred.

Discussion

Results from growth regulator studies support the theory (11, 12) that cytokinins play an essential role with auxins in bud development and also alter apical dominance. Cohen and Shanks (1) have reported that foliar applications of BA stimulated bud development in dwarf shoots of *Pinus ponderosa* even though terminal buds of long shoots were present.

Our present studies suggest that a similar mechanism of apical dominance via lateral bud inhibition exists in *Pinus strobus* and the level and type of cytokinin along with auxin within the bud during the growing season play an essential role in controlling bud development. This phenomenon was noted with those plants where terminal buds were pinched with only the upper 1 cm of stem initiating developed buds within the dwarf shoots. BA on the other hand, overcame complete apical dominance and stimulated bud development along the entire terminal stem. Treatments of BA at 500 and 1000 ppm were effective in enhancing bud development while PBA at 100 and 200 ppm was ineffective in our studies further suggesting a chemical interaction between the native and concn of cytokinins in stimulating bud development.

Results from the propagation studies show a strong clonal response in rooting probably due to genetic variation between the clones. It should be further noted that higher % rooting of certain clones could be influenced by the physical and nutritional status of dwarf shoots. Further investigation will be needed to define the parameters of propagation of dwarf shoots before this method can become commercially feasible.

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