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Effect of Benzyladenine on the Promotion of Bud Development and Branching of *Picea pungens*

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Abstract. ***Picea pungens*** **Englm. trees were treated with a single foliar spray of solutions containing 0, 100, 250, 500, and 1000 mM BA at 4 different times as follows during the growing season: 1) dormant trees, 2) at bud break, 3) during stem elongation, 4) summer hardwood, and 5) summer hardwood combined with a pruning. Treatments of 1000 mM at the time of bud break and to pruned summer hardwood trees resulted in an increase in bud number but not a corresponding increase in branch number the following year.**

Shearing is an important cultural practice in the production of coniferous trees. Shearing shapes and increases tree density, and the removal of the shoot apex promotes branching in trees with excurrent habits, such as conifers (3, 5, 11).

Exogenously applied cytokinins promote lateral bud growth and branching in woody plants (2, 6, 10, 12). Cytokinin applications promote the formation and out-growth of inhibited lateral buds of such diverse woody species as *Macadamia tetraphylla* L. (1), *Citrus reticulata* Blanco (8), and *Rosa hybrida* L. (9).

Apical dominance is not the only factor that determines branch number. The density of lateral buds produced along a shoot places limitations on the potential number of lateral branches that can be produced by the shoot. Unlike most angiosperms, which produce axillary buds at the base of each leaf, certain coniferous genera, including *Picea*, produce a large number of buds that are located in a pseudowhorl just below the terminal bud (4), and axillary buds are produced intermittently along the shoot.

The time of application of cytokinin treatments has an affect on the promotion of lateral shoot growth. Spring treatment of inhibited *Citrus* buds with the cytokinin BA was more effective than summer treatment (8). Cytokinin applications made to inhibited buds on dormant apple trees were more effective than applications made to trees which had begun to grow (12). In roses, the response of axillary buds to BA treatment was greatest at the time of shoot development, whereas treatments to mature canes at harvest time did not increase shoot production significantly as compared to an unpruned control (9). Spring treatments to *Pinus ponderosa* Laws. were more effective than fall treatments in promoting the formation of fascicular buds (3).

Although the optimum time of cytokinin treatment for stimulation of lateral shoot growth is not the same for all species, each species appears to have a growth period when it is most sensitive to cytokinin treatment. This study was designed to determine 1) if the application of BA in a single foliar spray is effective in increasing the number of branches produced by *Picea pungens*, and 2) the optimal time for this application to promote lateral bud and branch formation.

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Table 1. Effect of BA treatment on the number of buds produced per tree by *Picea pungens* August 1981 (5 months after treatment).

Time of application and BA concentration (mM)	Mean bud no.	R^2
Dormant		0.16
0	64.3	
100	65.5	
250	63.4	
500	66.0	
1000	69.7	
Bud break		0.36
0	66.6	
100	56.8	
250	66.1	
500	55.8	
1000	124.7*	
Springwood		0.12
0	56.9	
100	55.4	
250	52.8	
500	65.6	
1000	64.4	
Summer hardwood		0.20
0	54.7	
100	52.3	
250	60.3	
500	48.6	
1000	55.9	
Pruned summer hardwood		0.17
0	34.4	
100	34.8	
250	42.0	
500	48.3	
1000	51.0*	

*Significantly different from 0 mM BA level applied to the same developmental stage using contrasts at $P = 0.05$.

Two-year old bare root seedlings of *Picea pungens* were potted in 12 cm pots in 1 soil: 1 peat : 1 perlite (by volume) and grown in a glasshouse. Uniform plants were treated with a single foliar spray to incipient run-off of 0, 100, 250, 500, and 1000 mM BA in 9 water: 1 methanol (v/v). Solutions were applied at 4 different times during the growing season. Each treatment was replicated 3 times with 5 plants per replicate, arranged in a randomized block design. The treatments were: 1) dormant trees treated on 3 Mar. 1981; 2) immediately following bud break 23 Mar. 1981; 3) trees, whose current season's shoot growth had just finished elongating and con-

Table 2. Effect of BA on the height and branch number per tree of *Picea pungens* at different times after treatment.

Time of application & BA concentration (mM)	June 1981				June 1982			
	Height (cm)	R^2	Branch no.	R^2	Height (cm)	R^2	Branch no.	R^2
Dormant		0.34		0.19		0.32		0.16
0	28.59		26.4		40.79		56.8	
100	28.42		24.4		44.92		58.2	
250	26.12		24.5		39.92		53.6	
500	26.82		26.1		40.21		51.6	
1000	26.96		27.5		39.40		51.7	
Bud break		0.16		0.26		0.17		0.30
0	26.68		27.1		41.89		57.5	
100	25.35		22.0		47.15		46.9	
250	24.68		27.2		41.75		53.6	
500	25.35		23.4		45.27		50.3	
1000	24.50*		30.4		42.79		65.1	
Springwood		0.11		0.28		0.42		0.20
0	26.89		22.5		40.82		47.7	
100	26.43		20.9		42.83		50.6	
250	26.50		19.7		46.83		47.3	
500	26.64		24.9		46.71		54.6	
1000	26.36		23.3		47.00		55.4	
Summer hardwood		0.25		0.23		0.29		0.22
0	25.87		19.4		41.73		41.7	
100	25.63		18.3		40.13		39.5	
250	25.89		22.2		40.20		44.4	
500	25.30		19.6		38.37		37.3	
1000	25.50		19.3		38.17		38.3	
Pruned summer hardwood		0.09		0.11		0.37		0.12
0	25.13		18.3		42.90		44.8	
100	25.33		20.8		44.13		41.2	
250	24.77		20.7		40.00		44.2	
500	24.60		21.5		38.60*		47.9	
1000	24.93		21.1		42.07		45.6	

*Significantly different from 0 mM BA level applied to the same development stage using contrasts at $P = 0.05$.

tained stems still green and tender (springwood), treated 17 Apr. 1981; 4) trees, whose current season's growth was tan-colored and firm (summer hardwood), treated 18 May, and 5) trees pruned by removing about 2–3 cm of growth from the leader and lateral branches before treatment on 18 May.

Tree height and number of branches were recorded at the time of treatment and again at the end of the growing season. The number of buds on each tree was recorded in early August, after the completion of bud development.

In October, the trees were placed in an unheated polyhouse. In Feb. 1982, the trees were placed in a heated glasshouse under continuous incandescent light of 1.68 μmol $s^{-1}m^{-2}$ measured between 400–700 nM. The height and number of branches were measured at the end of the growing season.

For each treatment time the coefficient of determination was calculated and the 0 mM BA treatment mean was compared with each of the other BA treatment means using contrasts.

There were no significant differences in branch number of the trees at the time of treatment. Approximately one month after treatment, some of the trees with 500 and 1000 mM BA at the time of bud break began to develop bright red colored areas along portions of the stem on the current season's growth. The red coloration was more intense than could be ascribed to a failure of chlorophyll formation. Kossuth (7) noted a similar phenomenon with biweekly 23 and 225 ppm BA treatments to *Pinus sylvestris*.

Some of the red areas began to form buds 6 weeks after treatment. In most instances, the red area became a mass of small axillary buds. In a few extreme cases, more than one bud would form in a leaf axil. The uncolored areas formed relatively few buds. The proliferation and development of buds in these red areas was completed by August, 5 months after the initial treatment. This bud proliferation was most prominent on trees treated with 1000 mM BA.

The 1000 mM BA treatment applied at the time of bud break and 1000 mM BA applied to pruned summer hardwood trees resulted in a significant increase in the number of buds, as compared to the 0 mM BA applied to the same developmental stage. (Table 1). This increase primarily was due to the development of the axillary buds, although the 1000 mM BA treatment also increased terminal bud production. However, this increase in bud number did not result in an increase in branch number (Table 2). There was no correlation 3 or 15 months after treatment between BA treatment and total branch number. There also was no correlation between height and BA treatment.

These results show that a single application of BA to *Picea pungens* at the time of bud break and to pruned summer hardwood trees increased bud development; however, the induced buds failed to elongate the following growing season and did not result in increased branching. Linear regression analysis was used to analyze the relationship between bud formation and the number of branches that subsequently developed from the buds of trees treated at the time of bud break. For purposes of comparison, a similar linear regression analysis was conducted for trees treated during the dormant period. The coefficient of determination (R^2) for trees treated at bud break was 0.18 and $R^2 = 0.20$ for trees treated during dormancy, indicating that the relationship between bud number and resulting branch production is not linear.

These results demonstrate the need for treated plants to be observed for bud break the year following treatment. The data agree with Kossuth's (7) research that the stimulation of bud formation does not necessarily result in the long range goal of increased branching.

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