PROMOTING BUD DEVELOPMENT AND BRANCHING OF SCOTCH PINE WITH 6-BA[1]

by Susan M. Mulgrew and David J. Williams

Abstract. Scotch pine trees treated with different concentrations of 6-benzyladenine (6-BA), with 6-BA in combination with the surfactants Buffer X, Surfactant WK, Triton X-100, ABG 7001, ABG 7002, ABG 7003, and with 6-BA + Wilt-Pruf produced an increased number of fascicular buds. However, enhanced fascicular bud development either did not result in an increase in lateral branch number the following season, or resulted in the production of a large number of short branches which detracted from the appearance of the plant.

Coniferous trees used as Christmas trees and in landscape plantings are sheared during commercial production to improve the shape and density of the plants. The shearing process increases plant density by releasing the lateral buds from the inhibiting effects of apical dominance imposed by the shoot tip, enabling the lateral buds to develop into branches.

Cytokinin applications have been shown to promote lateral bud growth and branching in woody species such as apple (2, 6, 10, 12), *Macadamia* (1), *Citrus* (8), and rose (9). The authors hypothesized that some of the time and expense involved in shearing coniferous trees might be reduced with applications of cytokinins to the plants.

The genus *Pinus* is unique in that all of its photosynthetically active needles, except for the primary needles of young seedlings, are borne on lateral short shoots, which are also referred to as needle fascicles. The short shoot apex of pine is usually inactive, but may become reactivated under unusual circumstances (5). Applications of cytokinins to the needle fascicles have promoted the reactivation of the short shoot apex and the development of fascicular buds in several pine species (3, 4, 7, 11).

In previous studies investigating the use of cytokinins to promote bud development and branching of pine the cytokinin treatments were applied several times during the growing season or were selectively applied to specific parts of the shoot (4, 7, 11). A single foliar application would be a more practical and economical method of cytokinin application for use by commercial growers.

The objective of this study was to determine whether the application of a single foliar spray of the cytokinin 6-benzyladenine (6-BA) would be a practical commercial method for increasing branching of *Pinus sylvestris* (Scotch pine). The study was also conducted to determine whether 6-BA-induced branching and bud development of Scotch pine would be enhanced by the use of Wilt-Pruf, used as a spreader-sticker, and by the use of different surfactants. The effect of different 6-BA concentrations on bud development and branching was also investigated.

Methods

Wilt-Pruf. In June, 1981 2-year-old, container grown Scotch pine trees growing in 12-cm pots in a 1:1:1 by volume soil:peat:perlite medium and having begun their annual flush of growth, were brought into a greenhouse. The leader and lateral shoots were pruned in order to remove the terminal buds and the trees were treated with 0, 500, and 1000 ppm 6-BA and 0, 500, and 1000 ppm 6-BA in 10% Wilt-Pruf. Each solution also contained 0.5% Buffer X, a surfactant, which was used to prevent the precipitation of 6-BA. The solutions were applied to incipient runoff and each treatment was applied to 10 trees.

The trees were removed to an unheated polyhouse for overwintering in late October, 1981. In

[1] The authors wish to thank Abbott Laboratories for supplying the surfactants ABG 7001, 7002 and 7003 and for partial funding of this study.

January, 1982, after 2 months in the polyhouse, the trees were moved to a heated greenhouse and placed under continuous light in order to stimulate growth. In June, 1982 the height and number of branches of each tree were recorded.

Surfactants. In June, 1982 field studies were conducted to determine the effects of 6 different surfactants in a 250 ppm 6-BA solution on bud formation and branching of Scotch pine. Concentrations of 0.25, 0.50, and 1.00% of each surfactant were applied to incipient runoff to 3-year-old containerized trees growing in a composted hardwood bark medium in 20-cm pots. Each treatment was applied to 10 trees during the elongation of the current season's growth.

The surfactants used were Buffer X, Triton X-100, Surfactant WK, ABG 7001, ABG 7002, and ABG 7003.

In late July, 1982 the percent fascicular buds formed on the leader and the number of terminal buds on each leader were recorded. In June, 1983 the number of branches formed by each tree was counted.

Rate. For use in commercial production, it is more practical to express the amount of 6-BA applied as pt/A rather than ppm.

In May, 1982 pruned and unpruned 3-year-old containerized Scotch pine trees growing in a composted hardwood bark medium in 20-cm pots were treated with 0, 0.25, 0.50, and 100 pt/A of a 2.0% 6-BA solution manufactured by Abbott Laboratories (ABG-3034). Prior to treatment half of the trees, which had begun their annual flush of growth, were pruned by removing approximately one-third of the length of the leader and lateral branches. Each treatment was applied to 15 plants.

In late July, 1982 the percentage of fascicular buds that had formed on the leader were recorded. The following season in June, 1983, the number of branches formed by each tree was recorded.

Results

Wilt-Pruf. By July, 1981 all of the Scotch pine trees that had been treated with 6-BA, either with or without Wilt-Pruf, formed a large number of fascicular buds on the current season's shoot growth, while those trees that did not receive 6-BA treatment (the check and the 0.5% Buffer X + 10% Wilt-Pruf treatments) did not produce large numbers of fascicular buds.

In June, 1982 500 and 1000 ppm 6-BA treatments showed a significant increase in branch number as compared to the check (Table 1). The 1000 ppm 6-BA + Wilt-Pruf treatment also had a significantly greater number of branches, but this enhancement of lateral branching was not as great as the 500 and 1000 ppm 6-BA treatment.

Even though some of the treatments resulted in an increased number of branches, these branches were very short and were tightly crowded on the stem. Also, Scotch pine treated with 6-BA produced foliage that was short and chlorotic as compared to the check and the Wilt-Pruf + Buffer X treatments.

Wilt-Pruf did not enhance the effects of the 6-BA treatments since the 6-BA treatments that did not contain Wilt-Pruf produced a significantly greater number of branches as compared to the Wilt-Pruf + 6BA treatments (Table 1).

Surfactants. Analysis of the percent fascicular buds which formed on the leader of the Scotch pine trees indicates that solutions of 0.25% Buffer X and all of the Surfactant WK treatments resulted in a significant increase in the formation of fascicular buds as compared to the other surfactant treatments (Table 2). The number of lateral branches produced by the Scotch pine trees during the following season was not related to the fascicular bud development.

Rate. Both the rate of the 6-BA application and pruning were significant in promoting the develop-

Table 1. Effect of 6-BA and Wilt-Pruf on the height and branching of *Pinus sylvestris*.

Treatment	*Height*	*Branch no.*
Check	38.50a	18.5d
500 ppm 6-BA	33.80a	75.8b
1000 ppm 6-BA	35.25a	97.5a
Wilt-Pruf	37.35a	26.3d
500 ppm 6-BA + Wilt-Pruf	37.50a	24.0d
1000 ppm 6-BA + Wilt-Pruf	34.00a	43.3c

Mean separation within columns by Duncan's multiple range test, 5% level.

Table 2. Effect of six different surfactants on the formation of fascicular buds and terminal buds of *Pinus sylvestris*.

Surfactant conc. (%)	*Mean % fasc. buds*	*Mean no. term. buds*	*Branch no.*
Buffer x			
0.25	49.7 b	6.2 ab	53.1 ab
0.50	22.4 c	5.5 abc	55.6 ab
1.00	18.6 c	5.9 abc	43.4 ab
Triton X-100			
0.25	13.5 c	4.7 c	48.4 ab
0.50	7.9 c	5.7 abc	48.4 ab
1.00	18.4 c	5.9 abc	63.0 a
Surfactant WK			
0.25	46.0 b	5.0 abc	50.4 ab
0.50	71.4 a	6.2 ab	50.8 ab
1.00	63.9 ab	4.9 bc	49.4 ab
ABG 7001			
0.25	11.3 c	4.8 bc	45.3 ab
0.50	13.6 c	5.7 abc	50.9 ab
1.00	3.9 c	5.7 abc	60.1 ab
ABG 7002			
0.25	13.7 c	5.9 abc	55.1 ab
0.50	4.0 c	5.8 abc	57.5 ab
1.00	17.2 c	5.1 abc	52.4 ab
ABG 7003			
0.25	11.0 c	5.7 abc	47.5 ab
0.50	7.4 c	5.8 abc	50.3 ab
1.00	11.7 c	6.4 abc	42.5 b

Mean separation within columns by Duncan's multiple range test 5% level.

Table 3. The effect of three different rates of 6-BA on the percent of fascicular buds and number of terminal buds of *Pinus sylvestris*.

Rate	*Mean % fasc. buds*	*Mean no. term. buds*
Unpruned		
check	17.7 c	4.9 a
0.25 pt/A	12.8 c	4.5 a
0.50 pt/A	16.3 c	4.5 a
1.00 pt/A	20.9 c	4.1 a
Pruned		
check	45.5 b	0.0 b
0.25 pt/A	27.8 c	0.0 b
0.50 pt/A	51.9 ab	0.0 b
1.00 pt/A	61.5 a	0.0 b

Mean separation within columns by Duncan's multiple range test, 5% level.

ment of fascicular buds on the leader of Scotch pine (Table 3). There was no significant difference in the percentage of fascicular buds formed on unpruned plants, but on pruned plants there was an increase in the percentage of fascicular buds with increasing rates of 6-BA.

Branch counts taken the following season indicated that none of the treatments produced a significant increase in branch number as compared to the unpruned check (Table 4).

Discussion

Single foliar applications of the cytokinin 6-benzyladenine to Scotch pine trees were able to enhance fascicular bud production. This enhanced bud formation did not lead to an increase in branch number in the Surfactant and Rate experiments. The 6-BA-induced lateral branching of Scotch pine in the Wilt-Pruf experiment decreased the aesthetic value of the plants.

Although the surfactants used in this study did not produce an increase in branch number, the Buffer X and Surfactant WK treatments enhanced the fascicular bud development of Scotch pine as compared to the other surfactant treatments. Possible reasons for this difference include better contact between these surfactant solutions and the plant surface and/or greater penetration of the solutions into the plant tissue. Further work needs to be conducted to determine the mechanism of this response and to develop a method of inducing branch growth from the fascicular buds produced

Table 4. Effect of three rates of 6-BA on branch number of *Pinus sylvestris*.

Rate	*Branch*
Unpruned	
check	41.3 a
0.25 pt/A	43.9 a
0.50 pt/A	45.3 a
1.00 pt/A	49.6 a
Pruned	
check	41.4 a
0.25 pt/A	40.9 a
0.50 pt/A	50.7 a
1.00 pt/A	45.4 a

Mean separation by Duncan's multiple range test, 5% level.

in response to 6-BA treatment.

The variation in response of individual trees to 6-BA treatment poses another problem for the use of 6-BA in commercial production. The response of the trees to treatment must be predictable in order for 6-BA use to be commercially feasible. Since pine trees are often grown from seed, the genetic diversity of the crop is relatively high, and crop response to treatment is unpredictable. However, the large number of well developed fascicular buds that form in response to 6-BA treatment can potentially be used in the vegetative propagation of pine (3, 11), indicating that the 6-BA treatments may be better utilized as a means of generating large amounts of material for use in clonal propagation of superior pine trees.

The response of coniferous trees to 6-BA treatment may also be improved if the genetic uniformity of the crop were increased. Other possible areas of investigation include the use of split applications of 6-BA to promote the out growth of fascicular buds into branches and the application of 6-BA to a small section of the leader to induce the formation of a whorl of branches.

Literature Cited

1. Boswell, S.B., E.M. Nauer, and W.B. Storey. 1981. *Axillary buds sprouting in macadamia induced by two cytokinins and a growth inhibitor.* HortScience 16(1):46.
2. Broome, O.C., and R.H. Zimmerman. 1976. *Breaking bud dormancy in the crabapple (Malus hupenhensis (Pamp.) Rehd.) with cytokinins.* J. Amer. Soc. Hort. Sci. 101(1):28-30.
3. Cohen, M.A. 1978. *Shoot apex development and rooting of Pinus strobus L. by dwarf shoots.* J. Amer. Soc. Hort. Sci. 103(4):483-484.
4. Cohen, M.A., and J. Shanks. 1975. *Effect of N^6-BA, GA_3, and removal of terminal buds on dwarf shoot development in Pinus ponderosa.* J. Amer. Soc. Hort. Sci. 100(4):404-406.
5. Foster, A.S., and E.M. Gifford. 1974. Comparative Morphology of Vascular Plants. W.H. Freeman and Company, San Francisco. 751 pp.
6. Kender, W.J., and S. Carpenter. 1972. *Stimulation of lateral bud growth of apple trees by 6-benzylamino purine.* J. Amer. Soc. Hort. Sci. 97(3):377-380.
7. Kossuth, S.V. 1978. *Induction of fascicular bud development in Pinus sylvestris L.* HortScience 13(2):174-176.
8. Nauer, E.M., and S.B. Boswell. 1981. *Stimulating growth of quiescent citrus buds with 6-benzylamino purine.* HortScience 16(2):162-163.
9. Ohkawa, K. 1979. *Promotion of renewal canes in greenhouse roses by 6-benzylamino purine without cutback.* HortScience 14(5):612-613.
10. Richards, D. 1980. *Root-shoot interactions: effects of cytokinin applied to the root and/or shoot of apple seedlings.* Scientia Horticulturae 12:143-152.
11. Whitehill, S.J., and W.W. Schwabe. 1975. *Vegetative propagation of Pinus sylvestris.* Physiol. Plant. 35:66-71.
12. Williams, M.W., and H.D. Billingsley. 1970. *Increasing the number and crotch angles of primary branches of apple trees with cytokinins and gibberellic acid.* J. Amer. Soc. Hort. Sci. 95(5):649-651.

Graduate Research Assistant and
Associate Professor, respectively
Department of Horticulture
University of Illinois
Urbana, Illinois 61801