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Effect of Pruning, Defoliation, and Promalin on New Shoot Development of Boxwood[1]

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Abstract

The objective of this study was to determine if summer dormancy of the boxwood species *Buxus sempervirens* L. 'Suffruticosa', *B. sempervirens* 'Vardar Valley', and *B. sinica* var. *insularis* Nakai 'Justin Brouwers' could be overcome by pruning, defoliation or growth regulator applications. Promalin (benzyladenine (BA) + GA_{4+7}) alone and in combination with pruning increased new shoot growth; however, results were not consistent across experiments. Pruning alone (shearing or tip removal) was also inconsistent in inducing new shoot growth. Defoliation (removal of leaves from new spring growth) dramatically increased new shoot development, especially when applied ten weeks after spring budbreak instead of closer to budbreak. This response was tempered by Promalin application.

Index words: phytohormones, plant growth regulators, container-grown, nursery crops, woody ornamentals.

Species used in this study: English boxwood (*Buxus sempervirens* L. 'Suffruticosa'); Vardar Valley (*B. sempervirens* L. 'Vardar Valley'); and Justin Brouwers (*B. sinica* var. *insularis* Nakai 'Justin Brouwers').

Significance to the Nursery Industry

This research demonstrates that with the use of the growth regulator Promalin and/or pruning and defoliation, a second flush of growth during the growing season may be possible for boxwood. Defoliation was especially effective in increasing new shoot development and needs further investigation along with the effects of Promalin. A grower can potentially produce a larger plant in the same amount of time and increase revenues.

Introduction

Boxwoods typically produce a single flush of growth in the spring, and then shoot elongation and bud break cease. Plants remain dormant for the rest of the year, producing only slight, erratic growth. Lang et al. (13) defined dormancy as 'a temporary suspension of visible growth in any plant structure containing a meristem.' When dormancy is due to a stimulus that exists within the dormant plant structure, it is considered endodormancy. Paradormancy is regulated by physiological factors outside (para-) of the dormant structure, as with apical dominance (apical paradormancy). Production of auxin by the apical bud prevents the lateral buds from breaking. In this situation, the lateral bud is dormant and is under the external control of the apical bud (13).

A potential cause of boxwood summer dormancy may lie in the endogenous levels of various plant hormones since plant hormones regulate and coordinate plant metabolism, growth, and morphogenesis (20). Shoot pruning with some plants can be an effective method of inducing lateral shoot growth by releasing lateral buds from apical dominance (15).

Defoliating, as well as pruning a plant can affect hormonal levels and activity. In the tropics and subtropics, manual defoliation has been used to overcome floral bud dormancy of apple (*Malus* spp. Mill.) (4, 5, 21), peach (*Prunus persica* (L.) Batsch) (5, 7), and grape (*Vitus* spp. L.) (5) in order to produce two fruit crops in a given year without fulfilling the typical chilling requirement. Following defoliation of apple trees, the closed apical buds had three times the usual gibberellin concentration, a decrease in abscisic acid, and an increase in cytokinin compounds (4).

While endogenous plant hormones can be manipulated through the cultural practices described above, plant growth regulators (PGRs) can also be applied to alter plant hormonal activity. Promalin (Abbott Laboratories, North Chicago, IL) is a PGR that contains equal parts cytokinin (N-(phenylmethyl)-1H-purin-6-benzyladenine) and gibberellin (GA_{4+7}) (21). Promalin has been used to induce lateral shoot formation, shoot elongation, or both in many woody ornamentals including roses (9, 24), vinca (6), pear (11, 12), forsythia (8), scented boronia (14), Algerian ivy (1), hypericum (22), apples (3, 2, 21), pecan (10), photinia, nandina and Formosa azalea (12). Promalin has been used in combination with such cultural practices as defoliation, pruning, and nutrient application to induce shoot growth in horticultural plants. Theron's (21) work on apple revealed that treatments of defoliation and Promalin both induced lateral bud break, and that the effects were stronger when treatments were combined than when applied separately. This research suggests that the two causes of axillary bud dormancy relate to the presence of the subtending leaf and the bud's distance from the apex. In apples Promalin applications increased budbreak and branching, and a combination of leaf removal and Promalin induced uniform branch distribution (17).

Sabatinos (18) found that treating *Buxus sempervirens* with gibberellic acid increased plant height, stem length, total dry weight, shoot:root ratio, and shoot production. McVey and Wittwer (16) conducted a field study on several woody ornamental species, including *B. microphylla koreana*, and found that plants treated with 1000 ppm gibberellin yielded an open, leggy growth habit compared to those plants treated with 10 or 100 ppm, which were more uniform in their growth. A preliminary greenhouse experiment not reported here where Promalin was applied to 'Vardar Valley' boxwood at 1000 ppm, as well as applications of Promalin at 1000 ppm to

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English boxwood in a commercial nursery resulted in the stimulation of new shoot growth following the initial spring flush. Additional data are needed to determine if boxwood dormancy can be altered by hormonal manipulation. Therefore, the purpose of this research was to determine the effects of pruning, defoliation, and Promalin on boxwood growth.

Materials and Methods

Promalin and pruning. Branched rooted cuttings (8 months after rooting) of *B. sempervirens* 'Vardar Valley', *B. sinica* var. *insularis* 'Justin Brouwers', and *B. sempervirens* 'Suffruticosa' were potted on March 2, 2000, into 1 liter (1 qt) pots in a 100% pine-bark substrate. The substrate was amended per cu m (cu yd) with 3.6 kg (6 lb) of dolomitic limestone and 0.9 kg (1.5 lb) micromax (Scotts-Sierra Hort. Products Co., Marysville, OH). Each plant received a surface application of a 15N–3.9P–9.8K controlled-release fertilizer, Osmocote Plus (15N–9P_2O_5–12K_2O), (Scott-Sierra Hort. Products Co.) at 4 g (0.14 oz) per pot. Treatments were randomly assigned to 10, single-plant replications per treatment in 2 Promalin treatments (treated and untreated) × 2 pruning treatments (pruned and unpruned) factorial arrangement (= 4 treatments). The three species were separate experiments. The pruning treatment was performed on June 16, 2000, by pruning all plants to approximately 10-cm height [1 to 2 cm (0.4 to 0.8 in) of new growth removed]. On June 20, 2000, 210 ml (7.1 oz) of 1500 ppm Promalin solution containing 19% Tween 20 at 1 ppm was applied with a CO_2 sprayer to a 1 m^2 area containing the 10 plants. Initial shoot number was taken for all plants on June 30, 2000. Plants were glasshouse grown under natural photoperiod with day/night temperatures of approximately 26/21C (80/70F) and hand watered as needed. On October 20, 2000, at the termination of the experiment, a shoot count was taken for all plants, and the initial shoot number was subtracted from final shoot number to calculate the number of new shoots. Shoots of all plants were cut at substrate surface November 2, 2000, dried to a constant weight at 65C (150F), and weighed. All data were submitted to analysis of variance with mean separation by Duncan's multiple range test (SAS Institute Inc., Cary, NC, Release 8.2). For statistical analysis, a square root transformation was applied to all count data to make the variances independent of the mean. All count data were also coded by adding 0.5 to allow for analysis of counts of zero (19). Untransformed and non coded data are presented in figures.

Promalin, pruning and defoliation. Buxus sempervirens 'Vardar Valley' in 1 liter (1 qt) plastic pots received treatments of Promalin applications, pruning, and defoliation, each at three stages of growth: Stage 1) the end of the spring growth flush (shoots fully elongated, leaves fully expanded and light green in color) on April 3, 2001, Stage 2) three weeks following the end of the spring growth flush on April 24, 2001, and Stage 3) ten weeks following the end of the spring growth flush (woody tissue hardened, leaves dark green in color) on June 11, 2001. The different treatments of Promalin (2×), pruning (2×), or defoliation applications (2×) at each stage (3×) were in a factorial arrangement resulting in twenty-four treatments. Promalin was applied as above at a rate of 1000 ppm, with all plants receiving an application of a surfactant (19% Tween-20 at 1 ppm) following pruning and defoliation. The pruning treatment was performed by removing the apical bud with no foliage from each shoot. Defoliation was accomplished by removing all current season leaves from each shoot by hand. Leaves from the previous years' growth were not removed. On April 18, 2001, all plants received a single application of a 15N–3.9P–9.8K controlled-release fertilizer, Osmocote Plus (15N–9P_2O_5–12K_2O) (Scott-Sierra Hort. Products Co.) at 4 g (0.14 oz) per pot, and all plants received an application of 100 ml liquid fertilizer (10N–1.8P–4.9K; 10N–4P_2O_5–6K_2O) at 1000 ppm-N on April 18, 2001, and July 11, 2001. On the day of treatment for each stage, initial shoot number was taken. Plants were greenhouse-grown under natural photoperiod with day/night temperatures of approximately 26/21C (80/70F) and watered as needed with overhead irrigation. A completely randomized design with nine replications and one plant per experimental unit was used. On October 2, 2001, at the termination of the experiment, shoots were counted, and the initial shoot counts were subtracted to give the number of total new shoots. Also on this date, the number of total dead shoots was recorded for all plants. Shoots from all plants were cut at the substrate surface on October 9, 2001, dried at 65C (150F) to a constant weight and weighed. All data were submitted to analysis of variance (SAS Institute Inc., Cary, NC, Release 8.2). Count data were transformed and coded for statistical analysis as described above.

Results and Discussion

Promalin and pruning. There was no significant interaction between Promalin and pruning for new shoot number and dry weight. For all three cultivars, Promalin increased new shoot number (Fig. 1) and dry weight (Fig. 2). Pruning increased new shoot number for all three cultivars and dry weight for 'Vardar Valley,' but decreased dry weight for the other two cultivars.

Promalin, pruning, and defoliation. A three-way interaction ($P = 0.0001$) occurred between stage of application, defoliation, and Promalin for the number of new shoots. Defoliation dramatically increased new shoot numbers at all stages of development, but more so at stage 3 (Fig. 3). Defoliation produced the greatest number of new shoots developed at stage 3. However, when Promalin was applied with defoliation the number of new shoots was reduced by 49 and 76% for stage 1 and 3 respectively, compared to defoliation alone (Fig. 3). In addition, approximately six of these new shoots that developed died soon after they developed (data not shown) when Promalin and defoliation were applied together. Promalin or pruning, either alone or in combination did not increase new shoot development as in the first experiment (data not shown). Significant interactions occurred between pruning and defoliation and with Promalin and defoliation on shoot dry weight. Defoliation reduced shoot dry weight by 45% for nonpruned plants and only 20% for pruned plants (Fig. 4). Defoliation reduced shoot dry weight by 45% when Promalin was applied but only 23% without Promalin (Fig. 5).

New shoots that developed on treated plants (pruning, defoliation, or Promalin) were approximately 1 cm in length, resulting in a denser plant. There was little increase in plant height or width due to treatment.

Altering boxwood hormone level through pruning, defoliation, or Promalin application can lead to new shoot devel-

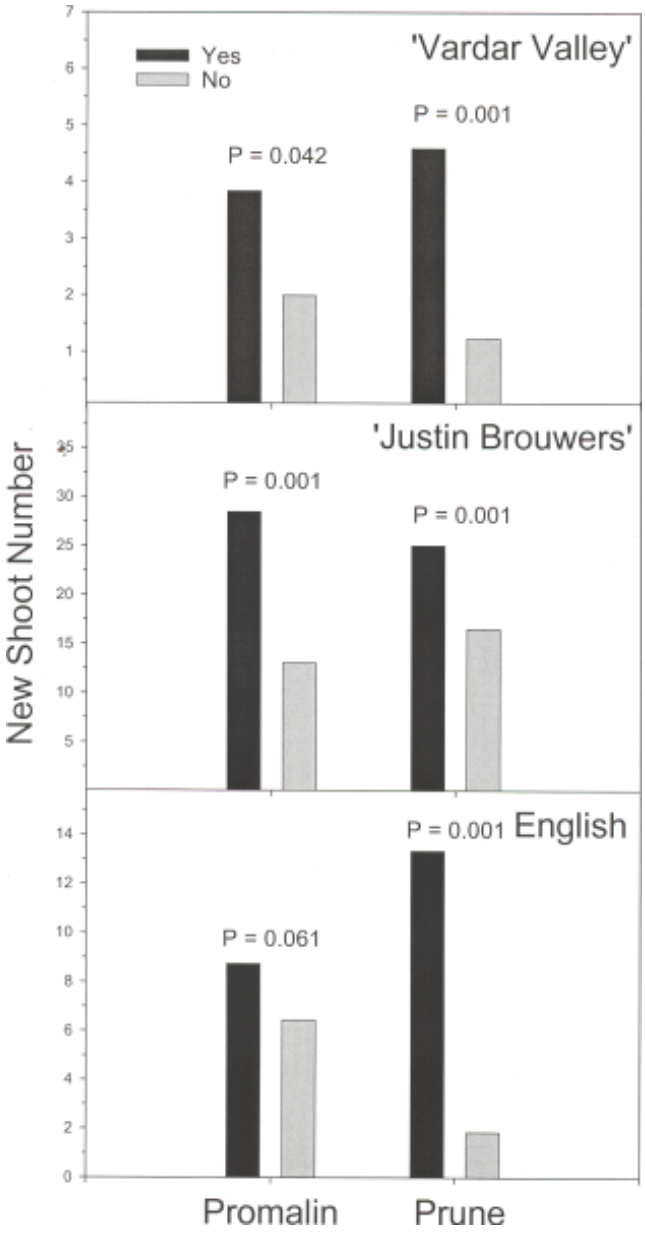

Fig. 1. Influence of Promalin and pruning on number of new shoots produced by a) 'Vardar Valley,' b) 'Justin Brouwers,' and c) English boxwood 20 weeks after treatment. P-values represent test for Promalin vs. no Promalin or pruning vs. no pruning. Promalin × pruning interaction was not significant at $\alpha = 0.05$.

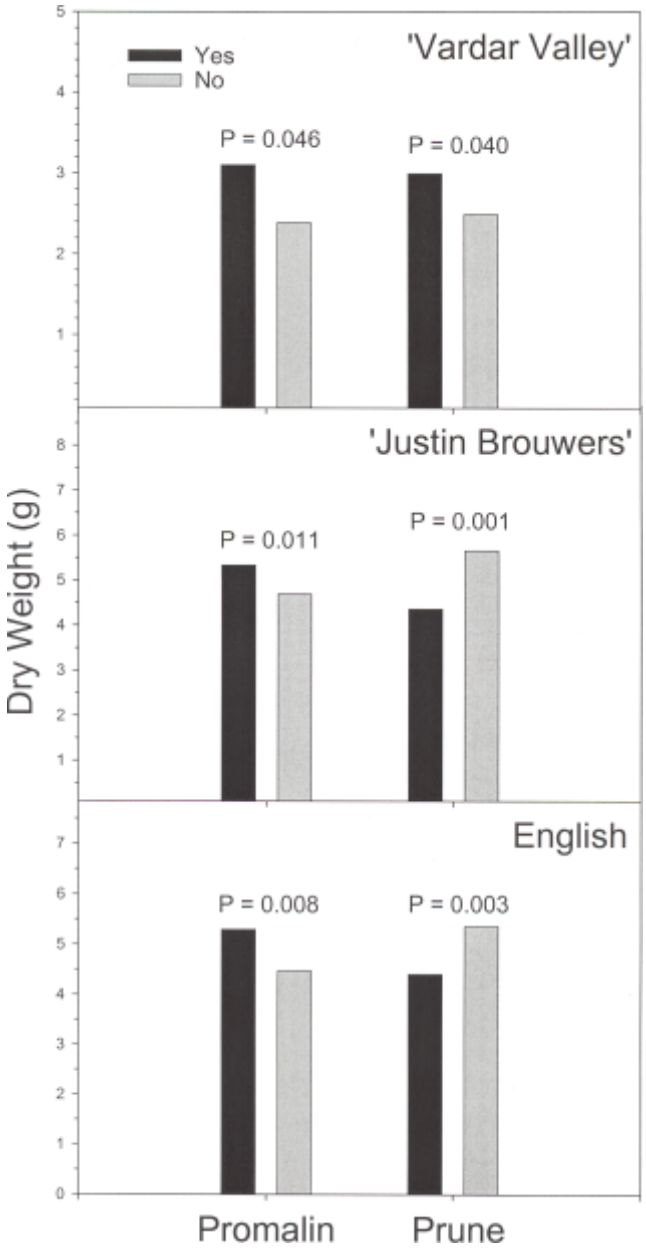

Fig. 2. Influence of Promalin and pruning on shoot dry weight 20 weeks after treatment for a) 'Vardar Valley,' b) 'Justin Brouwers,' and c) English boxwood. P-values represent test for Promalin vs. no Promalin or pruning vs. no pruning. Promalin × pruning interaction was not significant at $\alpha = 0.05$.

opment subsequent to the spring flush. Our results with the Promalin/pruning experiment showed both Promalin and pruning can be effective in increasing new shoot number in all three cultivars. However, in the Promalin/pruning/defoliation experiment neither Promalin alone or in combination with pruning were effective in producing new shoots. Promalin, therefore, may upon further investigations, be a commercially effective method of overcoming summer dormancy of boxwood and producing new shoot growth.

Defoliation was very effective in breaking summer dormancy of boxwood and producing a new shoot flush, a result consistent with that reported for other plants (4, 5, 7). However, new shoot development is not accompanied with vigorous elongation as occurs in the spring. Whether treatments that increase new shoot development have a positive effect on growth the following season would need to be considered and evaluated. Defoliation of boxwood to induce new shoot development may not be commercially feasible since hand defoliation utilized in this work is not practical. However, chemical defoliation might offer an effective less laborious means of defoliation. This approach needs to be investigated, given the dramatic increase in new shoot development with defoliation.

Pruning and defoliation reduced plant shoot dry weight relative to the control plants. Dry weight reduction from pruning for most woody plants that produce multiple flushes or growth continuously during the growing season is only temporary because the plant continues to grow rapidly for the

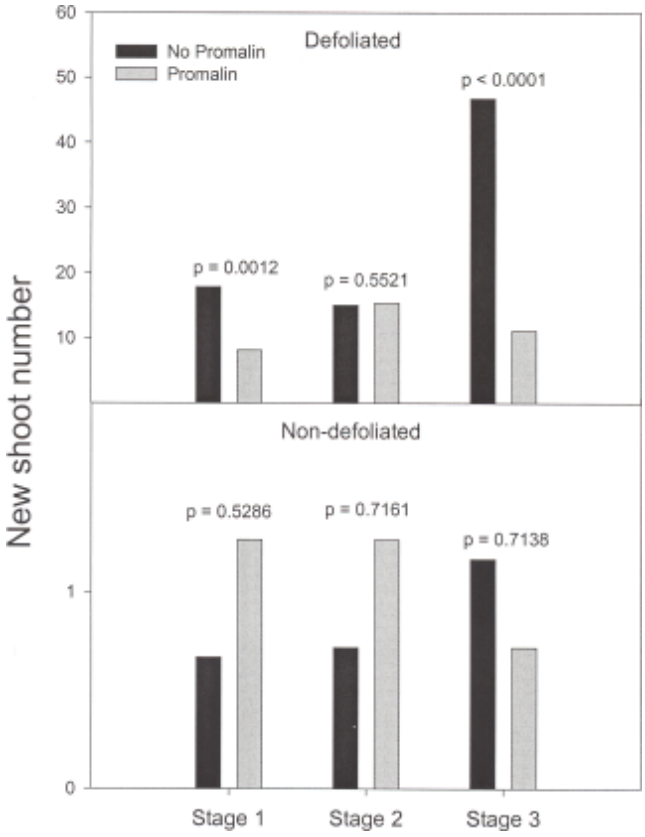

Fig. 3. Influence of Promalin, defoliation, and stage of growth (Stage 1: end of the spring growth flush, Stage 2: three weeks following the spring growth flush, and Stage 3: ten weeks following the end of the spring growth flush on number of new shoots produced on 'Vardar Valley' boxwood 26 weeks following treatment. Untransformed means presented here. P-values represent test for promalin effect within each stage.

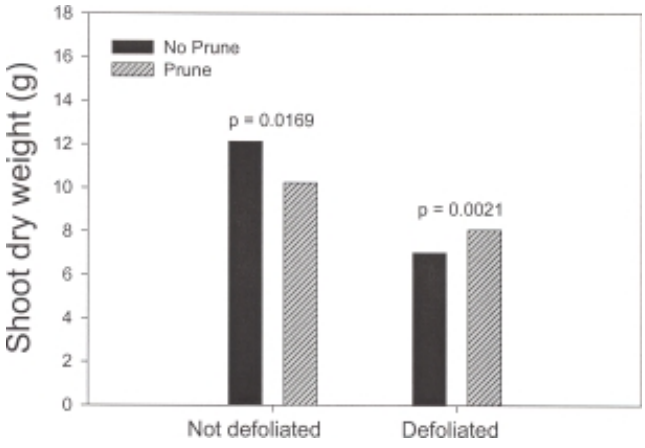

Fig. 4. Effect of pruning and defoliation on shoot dry weight of 'Vardar Valley' boxwood 26 weeks after treatment. P-values represent test for effect of pruning within non-defoliated and defoliated plants.

rest of the season. Final dry weight may be stimulated by pruning; however with boxwood, which experiences a type of summer dormancy, the effect of dry weight reduction by pruning or defoliation may be longer lasting (throughout that growing season).

When Promalin was applied in combination with defoliation, the number of new shoots produced decreased dramatically, the number of dead shoots increased from 0 to 6, and dry weight was decreased. While the reason for this response is unknown, it may be that endogenous hormone levels increased due to defoliation in conjunction with PGR (giberellin and/or cytokinin) applications, creating a toxicity. Edwards (4) showed that following defoliation, abscisic acid accumulation is reduced, and gibberellin and cytokinin levels increase. However, on peaches, combinations of Promalin and defoliation induced lateral budbreak more effectively than when applied separately (22). Whether Promalin and defoliation can be used effectively together on boxwood needs further investigation.

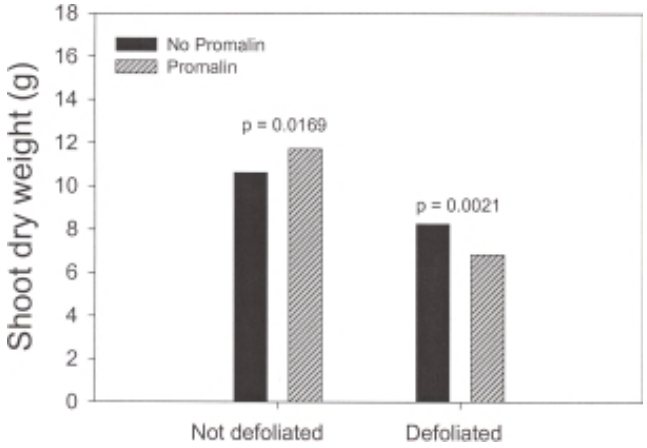

Fig. 5. Influence of Promalin and defoliation on shoot dry weight of 'Vardar Valley' boxwood 26 weeks following treatment. P-values represent test for effect of Promalin within non-defoliated and defoliated plants.

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