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# Sumagic (Uniconazole) Promotes Flower Bud Set on *Camellia japonica*[1]

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## Abstract

Three-year-old container-grown plants of *Camellia japonica* 'Grace Albritton', 'Paulette Goddard', and 'Sea Foam' were sprayed with a water control, B-Nine (daminozide) at 5000 ppm, Bonzi (paclobutrazol) at 80, 120, 160, 200, and 240 ppm, or Sumagic (uniconazole) at 30, 45, 60, 75, and 90 ppm in June. B-Nine and Bonzi treatments provided no increase in flower bud set but Sumagic treatments increased bud set for 'Grace Albritten' by up to 370% and 'Paulette Goddard' by 200%. In another experiment, Sumagic at 0, 45, 60, 75, and 90 ppm was applied to 'Grace Albritton', 'Paulette Goddard', and 'Blood of China' at three different spring growth stages: Bud swell, partial new shoot growth, and new shoots fully extended. Significant linear or quadratic increases in flower bud set occurred for all cultivars depending on application timing. Application at the two earlier stages resulted in more flowers than application at the latest (full shoot growth) stage. Sumagic decreased plant heights by 10 to 30%, depending on cultivar and application rate but this reduced the need for shearing to maintain form and compactness and made flowers more visible over the surface of the plants.

**Index words:** plant growth retardants, plant growth regulators.

**Species used in this study:** 'Blood of China', 'Grace Albritton', 'Paulette Goddard', and 'Sea Foam' camellia (*Camellia japonica* L.).

**Chemicals used in this study:** B-Nine (daminozide), butanedioic acid mono (2,2-dimethylhydrazide); Bonzi (paclobutrazol), 2RS,3RS-1-(4-chlorophenyl)-4,4-dimethyl-2-(1,2,4-triazol-1-yl)pentan-3-ol; Sumagic (uniconazole), (E)-1-(p-chlorophenyl)-4,4-dimethyl-2-(1,2,4-triazol-1-yl)-penten-3-ol.

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### Significance to the Nursery Industry

During container production of camellias, some vigorously-growing cultivars are slow to begin flowering. Plants that are at a marketable size but not yet flowering are more difficult to sell because most customers prefer to purchase plants that are flowering or are ready to flower. A 45 ppm Sumagic spray applied to plants in the spring just before or during the first growth flush resulted in a 250 to 500% increase in flower bud set over untreated controls, later in the year. The flowers opened normally and with normal size and appearance. Plant heights were reduced by about 20 to 25% but this had the benefit of producing more compact plants with more visible flowers, without the need for shearing. This should increase marketability for wholesale and retail sales.

### Introduction

There are many desirable cultivars of *Camellia japonica*, evergreen shrubs valued for their showy flowers. The flower buds of *C. japonica* are normally set in late summer and open the following winter to early spring. When produced in containers for transplanting into the landscape, most cultivars begin to set flower buds within 2 to 3 years after propagation by cuttings, at which time they are ready for sales. However, some desirable cultivars are slow to begin flowering in production, failing to flower or flowering sparsely even after 3 years. This makes them unacceptable for sales and increases production costs due to increased production time required to bring them to an acceptable level of flower bud set. It is not clear what controls the ability to initiate flowers in woody plants, however, attainment of sufficient size appears to be more important than a plant's chronological age in determining transition to the flowering phase (14). Competence to flower may also depend on specific environmental, as well as developmental signals (9, 14). Bonner (3) showed that *C. japonica* requires day temperatures of 27C (80F) or more and night temperatures of at least 16C (60F) to initiate flower bud formation, with long photoperiods producing more buds than short (8 hr) photoperiods. Gibberellin biosynthesis inhibitors of the triazole group, which includes Sumagic (uniconazole) and Bonzi (paclobutrazol), have been used to promote flowering of woody nursery crops such as *Rhododendron* (2, 4, 5), and *Kalmia* (1, 4), as well as *Camellia sasanqua* (7), and *Camellia* x *williamsii*, a hybrid of *C. japonica* and *C. saluenensis* (15). These products also suppress stem elongation on many different crop species, including several woody landscape plants (6, 8, 11, 12). Some growth suppression can be desirable as long as overall plant size is not excessively affected. Young camellia plants tend to grow vigorously and may require shearing to maintain a compact shape. Long stems may also droop under the weight of developing flowers (15). The objective of this study was to investigate the use of growth regulators to increase flower bud set on camellia cultivars that are slow to begin flowering, and to maintain compact growth without excessively reducing overall plant size.

### Materials and Methods

*Experiment 1.* Based on records of the cooperating nursery (Bennett's Creek Wholesale Nursery, Inc., Suffolk, VA), three *Camellia japonica* cultivars were selected that are slow to set flower buds: 'Grace Albritton', 'Paulette Goddard', and 'Sea Foam'. The plants were growing in 11.4-liter (#3)

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containers in a medium of 92% aged pine bark and 8% coarse sand, amended with 5.4 kg/m³ (9 lb/yd³) Osmocote 18N–2.6P–10K (18–6–12, Scotts-Sierra Horticultural Products Co., Marysville, OH) and 0.9 kg/m³ (1.5 lb/yd³) Micromax (Scotts-Sierra Co.). They were maintained in shade houses under 50% shade during the summer months. During the winter, the houses were covered with white polyethylene. These plants were three years from propagation by cuttings but had not yet initiated flower buds. Just prior to treatment, the plants were lightly sheared to uniform heights (from the container medium surface) of about 63 cm (25 in), 61 cm (24 in), and 65 cm (26 in) for 'Grace Albritton', 'Paulette Goddard', and 'Sea Foam', respectively. On June 4, 2001, growth regulator spray treatments were applied with a $C0_2$-pressurized sprayer at 207 KPa (30 psi) to uniformly wet the foliage and stems (approx. 40 ml/plant). Temperature at time of application was 27C (80F) and relative humidity was 70%. Treatments included Bonzi (paclobutrazol) applied at 80, 120, 160, 200, and 240 ppm, Sumagic (uniconazole) at 30, 45, 60, 75, and 90 ppm, B-Nine (daminozide) at 5000 ppm, and a water (0 ppm) control spray. The B-Nine treatment was reapplied on June 22. The experimental design was a randomized complete block within cultivars with eight single-plant replications per treatment. Plant heights (from the surface of the container medium) and widths [(widest width + width perpendicular to widest width) / 2] were measured on September 28, 2001, and flower buds were counted February 13, 2002. Data were analyzed with the SAS GLM procedure (13) with PGR concentration responses determined by orthogonal polynomial contrasts. The control treatment was included in the analysis. Each cultivar was analyzed as a separate experiment.

*Experiment 2.* This experiment was conducted in 2003. The cultivars 'Grace Albritton' and 'Paulette Goddard' were also used in this experiment but 'Blood of China' was substituted for 'Sea Foam' because 'Sea Foam' was unavailable in sufficient quantities. All plants were 3 years from propagation by cuttings, growing in 11.4-liter (#3) containers with the same container medium and under the same cultural conditions as described for experiment 1. Spray treatments were Sumagic at 0 (water control), 45, 60, 75, and 90 ppm applied as described for experiment 1 except that the treatments were applied at three different spring growth stages (three different dates). Application stage 1 was at bud swell (April 18). Plant mean heights (from the surface of the container medium) at this stage were 52 cm (20.5 in), 42 cm (16.5 in), and 44 cm (17.3) for 'Grace Albritton', 'Paulette Goddard', and 'Blood of China', respectively. Stage 2 was new shoot growth partially extended (May 5). The new shoot extension at this stage, compared to the fully extended mature shoot length, was 77% for 'Grace Albritton', 56% for 'Paulette Goddard', and 39% for 'Blood of China'. Plant mean heights at stage 2 were 63 cm (24.8 in), 51 cm (20 in), and 50 cm (19.7 in), for 'Grace Albritton', 'Paulette Goddard', and 'Blood of China', respectively. Stage 3 was when new shoots were fully extended and new leaves were at or near their final size (May 28). Mean plant heights were 67 cm (26.4 in), 64 cm (25.2), and 60 cm (23.6) for 'Grace Albritton', 'Paulette Goddard', and 'Blood of China', respectively. In order to eliminate the possibility of shearing affecting treatment results, plants were not sheared prior to treatment at any of the application stages. The stage 1 applications were not made to 'Blood of China' due to unavailability of plants at that time. On October 8, plant heights and widths [(widest width + width perpendicular to the widest width) / 2] were measured and the flower buds were counted. Treatments in this 3 × 5 factorial experiment (3 application stages and 5 Sumagic concentrations) were arranged in a randomized complete block design with eight single-plant replications. Cultivars were randomized

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**Table 1. Effects of Bonzi (paclobutrazol), Sumagic (uniconazole), or B-Nine (daminozide) on plant size and flower bud set of *Camellia japonica* 'Grace Albritton' and 'Paulette Goddard'.**

| | | 'Grace Albritton' | | | 'Paulette Goddard' | | |
|---|---|---|---|---|---|---|---|
| Growth regulator | Conc. (ppm) | Flower bud counts | Height (cm) | Width[z] (cm) | Flower bud counts | Height (cm) | Width (cm) |
| Control | 0 | 6 | 116 | 50 | 3 | 75 | 51 |
| B-Nine | 5000 | 5 | 109 | 49 | 3 | 70 | 54 |
| Bonzi | 80 | 6 | 105 | 50 | 3 | 74 | 54 |
| | 120 | 8 | 105 | 50 | 4 | 69 | 47 |
| | 160 | 7 | 109 | 48 | 3 | 66 | 51 |
| | 200 | 8 | 102 | 52 | 7 | 71 | 53 |
| | 240 | 12 | 109 | 51 | 3 | 76 | 52 |
| | | NS[y] | NS | NS | NS | Q* | NS |
| Sumagic | 30 | 11 | 94 | 40 | 9 | 59 | 50 |
| | 45 | 22 | 98 | 46 | 7 | 58 | 50 |
| | 60 | 20 | 96 | 42 | 8 | 61 | 52 |
| | 75 | 24 | 96 | 44 | 7 | 53 | 46 |
| | 90 | 28 | 93 | 43 | 9 | 51 | 45 |
| | | L*** | L** | NS | NS | L*** | L* |

[z]Width = (widest width + width perpendicular to widest width) / 2.

[y]Trend response non-significant (NS), linear (L), or quadratic (Q) at $P = 0.05$ (*), 0.01 (**), or 0.001 (***) determined by orthogonal polynomial contrasts. Control included in analysis.

separately and analyzed as separate experiments. Significance of main effects and interactions was determined by analysis of variance using the SAS GLM procedure (13). Orthogonal polynomial contrasts were used to determine Sumagic concentration responses. Comparison of growth stages was by LSD, $P = 0.05$, when appropriate.

## Results and Discussion

*Experiment 1.* 'Sea Foam' showed no response to any of the treatments (data not shown). When plants were treated with B-Nine, there were no significant effects on flower bud counts or plant size with any of the cultivars treated (Table 1). With Bonzi, there were no increases in flower bud counts or plant widths but the heights of 'Paulette Goddard' treated with 120 and 160 ppm Bonzi were less than for the control plants, resulting in a quadratic response to Bonzi concentrations (Table 1). However, these height differences could be from variability due to other factors as there was no significant height reduction at the highest Bonzi concentration (240 ppm). It may be that the concentrations of Bonzi used were not high enough. Wilkinson and Richards (15) obtained a significant increase in flower bud set on *C.* x *williamsii* 'Debbie' with a single Bonzi spray of 500 ppm. Our treatments were all less than half that concentration.

Increasing concentrations of Sumagic resulted in a linear increase in flower bud numbers on 'Grace Albritton' from 6 buds per plant for the control to 28 buds per plant at 90 ppm (Table 1). Even the 45 ppm treatment resulted in 22 buds per plant, a 3.5-fold increase over the controls. Sumagic treatments to 'Paulette Goddard' provided bud counts of 7–9 buds per plant compared to 3 buds per plant for the controls but this was not a significant concentration trend response. Significant but not excessive reductions in plant heights up to 30% for 'Grace Albritton' and 'Paulette Goddard' also occurred with the Sumagic treatments, and there was a linear decrease in plant widths for 'Paulette Goddard'. However, 'Sea Foam' showed no response to these treatments (data not shown). The differences in response of the three cultivars to the Sumagic treatments could be due to physiological differences among the cultivars but it could also be due to differences in new shoot growth at time of treatment application. The vegetative buds of 'Grace Albritton', the most responsive cultivar, were swelling but new shoot growth had not yet begun. The other two cultivars had new shoot growth several centimeters in length at the time of application. The question of optimal growth stage at treatment application was addressed in experiment 2. Shearing could also have been a factor. The practice of the nursery is to lightly shear following a growth flush to maintain plant shape. This occurred prior to treatment application. However, since new growth had not yet occurred on 'Grace Albritton', those plants would have received little, if any shearing. Banko and Bir (1) found that shearing of new shoots of *Kalmia* prior to treatment with Sumagic reduced the promotion of flower bud set the following late summer. Camellia bud set may be similarly affected.

**Table 2. Effects of Sumagic (uniconazole) foliar applications at different new shoot growth stages on flower bud set of *Camellia japonica*.**

| Application stage (date) | Sumagic conc. (ppm) | Flower bud counts: 'Blood of China'[z] | Flower bud counts: 'Paulette Goddard' |
|---|---|---|---|
| Bud swell (4-18-03) | 0 | — | 9 |
| | 45 | — | 38 |
| | 60 | — | 36 |
| | 75 | — | 42 |
| | 90 | — | 45 |
| Significance[y] | | | L**** |
| Partial new shoot growth (5-5-03) | 0 | 10 | 7 |
| | 45 | 36 | 32 |
| | 60 | 45 | 35 |
| | 75 | 54 | 32 |
| | 90 | 42 | 29 |
| Significance | | Q* | Q*** |
| New shoots fully extended (5-28-03) | 0 | 7 | 7 |
| | 45 | 13 | 18 |
| | 60 | 24 | 21 |
| | 75 | 20 | 13 |
| | 90 | 22 | 22 |
| Significance | | L** | L** |

[z]'Blood of China' not treated at bud swell stage.

[y]Linear (L) or quadratic (Q) response at $P = 0.05$ (*), 0.01 (**), 0.001 (***), or 0.0001 (****) determined by orthogonal polynomial contrasts. Control included in analysis.

*Experiment 2.* For flower bud counts, there were significant application stage by Sumagic concentration interactions with 'Blood of China' ($P = 0.02$) and 'Paulette Goddard' ($P = 0.006$), and highly significant ($P < 0.0001$) main effects for application stage and treatment concentration with 'Grace Albritton'. 'Blood of China' was not treated at stage 1 (bud swell) but 'Paulette Goddard' had a linear increase in bud counts with increasing Sumagic concentration when applied at stage 1 (Table 2). Flower bud counts increased from 9 for the controls to 45 at 90 ppm. Applications at stage 2 (partial new shoot growth) resulted in quadratic increases in bud counts with increasing treatment concentrations for both 'Blood of China' and 'Paulette Goddard'. Highest bud counts occurred at 75 ppm for 'Blood of China' and at 60 ppm for 'Paulette Goddard'. Applications at stage 3 (shoots fully extended) again provided a linear response with these two cultivars. Applications at this stage generally resulted in fewer flower buds than treatments at comparable rates applied at the two earlier stages. This observation is confirmed with the application stage main effects results seen with the cultivar 'Grace Albritton' which show flower bud counts from the earliest two application stages to be approximately twice that of the last (fully extended) stage (Table 3). These results are consistent with those of Keever and Olive (8) who found that Sumagic applications to azaleas at early (vegetative) growth stages produced more flowers and more compact plants than later stage applications. Increases in Sumagic concentration applied to 'Grace Albritton' over all application stages gave a quadratic increase in the flower bud counts with the largest number of buds (43) occurring at 90 ppm (Table 3). There were no significant main effects on plant widths for any of the cultivars and no significant interactive effects on plant heights or widths (data not shown). However, Sumagic applications reduced heights of all cultivars at all concentrations applied (Table 4), with specific responses differing for each cultivar. Height reduction responses to



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Table 3. **Bud count responses of 'Grace Albritton' camellia to Sumagic application stage (over all concentrations) and Sumagic concentration[z] (over all application stages).**

| Application stage (date) | Flower bud count |
|---|---|
| Bud swell (4 – 18 – 03) | 43a[y] |
| Partial new shoot growth (5 – 5 – 03) | 48a |
| New shoots fully extended (5 – 28 – 03) | 23b |
| **Sumagic concentration (ppm)** | |
| 0 | 8 |
| 45 | 38 |
| 60 | 34 |
| 75 | 37 |
| 90 | 43 |
| Significance[x] | Q* |

[z]Application stage × concentration interaction was not significant for 'Grace Albritton' flower bud counts.

[y]Mean separation within column by LSD, $P = 0.05$ (0 ppm control treatment not included in application stage comparisons).

[x]Concentration response quadratic (Q) at $P = 0.05$ (*) (0 ppm control included).

Sumagic concentration increase were linear for 'Blood of China', quadratic for 'Paulette Goddard', and cubic for 'Grace Albritton'. The cubic response for 'Grace Albritton' is apparently due to an unusually low height value for the 45 ppm treatment resulting from high variability of plant heights within that treatment. This prevents what would otherwise be a linear response. Although heights of treated plants were from 10 to 30% less than the control plants, depending upon cultivar and Sumagic concentration, they had a fuller, more compact appearance, with the added benefit of the flowers being more visible.

Application stage had a significant effect on heights of 'Paulette Goddard' and 'Grace Albritton' but not 'Blood of China' (Table 4). 'Paulette Goddard' plants were taller when Sumagic application was at stage 3 (shoots fully extended) than when at stage 1 or 2. This would be expected since the growth of fully-extended shoots would be unaffected by the treatment while growth of un-extended or partially-extended shoots would be expected to be retarded. Application to 'Grace Albritton' at Stage 3 resulted in taller plants than at stage 2 but the tallest plants were obtained with application at stage 1 (bud swell). This was unexpected. Possibly the second growth flush made up for any growth retardation that occurred to the first flush that followed treatment. In any case, the growth stage at Sumagic application did not have a major impact on overall plant size at the end of the growing season for any cultivar.

The results of this study show that an application of Sumagic early in the growing season can promote a large increase in flower bud set on *Camellia japonica* that are slow to begin flowering in production. The results agree with previous work with Sumagic to promote flower bud initiation on camellia and other woody species (1, 2, 4, 5, 7, 8, 10). The largest number of flowers occurred when applications were made in the spring just prior to the first growth flush (bud swell) or soon after growth started, although significant but smaller increases also occurred if applications were made soon after new growth was fully extended. A Sumagic spray of 45 ppm applied during stage 1 or 2 resulted in a 250 to 500% increase in flower bud numbers but with a reduction in plant height of 10 to 30 %, depending on cultivar. However, the height reduction had the advantage of producing more compact plants with increased flower visibility, without the need for shearing.

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Table 4. ***Camellia japonica* plant height responses to Sumagic concentration (over all application stages) and application stage[z] (over all concentrations).**

| | Plant heights (cm) | | |
|---|---|---|---|
| **Sumagic concentration (ppm)** | **'Blood of China'** | **'Paulette Goddard'** | **'Grace Albritton'** |
| 0 | 108 | 93 | 121 |
| 45 | 87 | 70 | 98 |
| 60 | 86 | 67 | 109 |
| 75 | 80 | 65 | 105 |
| 90 | 77 | 65 | 103 |
| Significance[y] | L**** | Q*** | C** |
| **Application stage (date)** | | | |
| Bud swell (4 – 18 – 03) | — | 65.3b | 110.4a |
| Partial new shoot growth (5 – 5 – 03) | 82.7a[x] | 62.8b | 96.2b |
| New shoots fully extended (5 – 28 – 03) | 81.9a | 71.8a | 104.5a |

[z]Application stage × concentration interaction was not significant for plant heights.

[y]Concentration response linear (L), quadratic (Q), or cubic (C) at $P = 0.01$ (**), 0.001 (***), or 0.0001 (****) determined by orthogonal polynomial contrasts. Control included in analysis.

[x]Mean separation within columns by LSD, $P = 0.05$ (0 ppm control not included in application stage comparison). Application not made to 'Blood of China' at bud swell stage.



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