use of CaCl₂ sprays or 15-0-15 fertilization enhanced branching only in Glory plants. *pH effects.* No significant effects of the different fertilizers on *pH* were observed. The *pH* of all treatments was in the acceptable range, although the *pH* of the Ca(NO₃)₂-fertilized plants was higher (6.8) than that of the other treatments (6.3-6.5). The initial *pH* for all treatments was 6.0. The rise in *pH* was attributed to the *pH* of the irrigation water, which was found to have an average *pH* of 7.4.

Enhanced branch retention in poinsettia fertilized with Ca(NO₃)₂ may be related to more efficient Cu uptake. Depressed Cu levels have been associated with high levels of *N* fertilization (15) and the lower cation content in poinsettia (15). Calcium cannot be taken up as rapidly as required when plants are grown under high *N* levels (12) and a competition exists between NH₄⁺ and Ca²⁺ ions for uptake (11). High *N* levels also inhibit root growth, which in turn impairs Cu uptake. Ammonium nitrate can induce water stress in poinsettias, a condition under which Cu uptake becomes inefficient (7). Water stress is not associated with nitrate fertilizer, so efficient Cu uptake is maintained.

Nitrogen supplied as Ca(NO₃)₂ may alleviate these problems by providing a constantly available supply of Ca in the soil. Also, the efficiency of Ca²⁺ uptake is improved by the higher levels of nitrate ions in the soil and the lower levels of NH₄⁺ ions present to compete with Ca²⁺ ions for uptake. This study indicates that the Ca-supplemented poinsettias were able to meet Ca requirements as needed during growth, resulting in attractive plants with enhanced stem retention.

### Literature Cited


**Fertilization Practice and Foliar-bract Calcium Sprays Reduce Incidence of Marginal Bract Necrosis of Poinsettia**

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Additional index words. *Euphorbia pulcherrima*, nutrient deficiency, ammonium

**Abstract.** Foliar-bract calcium (Ca) sprays and fertilization practices that altered Ca availability and supply were evaluated for their effect on marginal bract necrosis of ‘Gutbier V-14 Glory’ poinsettia (*Euphorbia pulcherrima Willd.*). About 90% fewer marginal necrotic lesions were observed on plants receiving an 81% NO₃⁻-N and 903-ppm Ca soluble fertilizer with 10% of the total nutrients foliar-applied than on plants grown with medium-applied Osmocote 19N-2.6P-10K (47% NO₃⁻-N) or with medium-applied liquid fertilizer containing 30% or 65% NO₃⁻-N and 0 ppm Ca. Addition of 354 ppm Ca in a 53% NO₃⁻-N, or 964 ppm Ca in a 75% NO₃⁻-N medium-applied fertilizer did not significantly reduce the number of lesions compared to the same fertilizer with 0 ppm Ca or the equivalent rate of a 53% NO₃⁻-N Osmocote 14N-6.1P-11.6K. Weekly foliar-bract sprays of 432 ppm Ca from Ca(NO₃)₂·4H₂O reduced numbers of lesions by 94% (1.5 lesions per plant), regardless of fertilization practice. Thus, soil applications of Ca were not effective in preventing marginal bract necrosis, whereas foliar applications of Ca were highly efficacious.

Marginal bract necrosis is a characteristic problem of ‘Gutbier V-14 Glory’ poinsettia (Wilfret, 1981). Woltz and Harbaugh (1986) determined that marginal bract necrosis was an expression of Ca deficiency in the bracts. Nell and Barrett (1985, 1986) reported that frequent irrigation, heavy fertilization during bract formation, using 100% NH₄-N or two Osmocote applications increased the incidence of bract necrosis. These cultural practices may decrease the uptake of Ca while stimulating large and rapid bract formation; thus, they may have increased bract necrosis. The following tests were performed to evaluate the interactive effects of fertilization practices and foliar Ca sprays on bract necrosis incidence and vegetative and flowering characteristics of ‘Gutbier V-14 Glory’ poinsettia. Fertilization regimes were chosen to: 1) evaluate practices that decrease *N* supplied as NH₄-N, while increasing soluble Ca; 2) be compatible with commercial practices used in the industry; 3) provide similar seasonal N-P-K per pot.

Two experiments were conducted in a fan- and pad-cooled glasshouse with temperatures ranging from 19°C (night) to 35°C (day). Shade was provided by exterior paint on the glass. Interior PAR at 1300 μmol-s⁻¹-m⁻² on hazy to clear days. Humidity ranged from 60% day to 98% night. Vents were generally closed at night, and supplemental heat was needed only a few nights during each experiment.

‘Gutbier V-14 Glory’ poinsettias were grown as single pinched plants (five nodes) in 15-cm pots (1.6 liters). Irrigation was with 38 × 38-cm pieces of capillary mat for each pot, with trickle tubes providing water to the mats. Plant spacing was 40 cm. A 2-cm gap between mats prevented fertilizer movement among pots. Fertilizer solutions were applied as 200-ml aliquots to each pot. Sources of N, P, and K are given in Table 1.

In the first experiment, rooted cuttings were...
planted on 12 Sept. and plants were pinched on 24 Sept. Anycymid growth retardant (0.25 mg per pot, soil drench) was applied 25 Oct. Potting medium was a volume mix of 5 Florida sedge peat : 3 horticultural grade vermiculite : 3 builders' sand : 1 perlite amended on a cubic-meter basis with 11.8 kg of dolomite, 3 kg of single superphosphate, and 0.9 kg of Micromax minor element mix (Sierra Chemical Co., Milpitas, Calif.). Liquid fertilization treatments (Table 1) initiated on 18 Sept. were applied weekly for 13 weeks and provided 93% of the per-pot per-season N–P–K supplied by 9.4 kg Osmocote 19N–2.6P–10K/m³ of medium. One-half of the Osmocote was incorporated in the medium at planting and half top-dressed on 7 Nov. Treatments were replicated six times in a randomized block design with a single plant as the experimental unit. Plant height, plant width, a subjective plant quality rating (1 to 5, with 5 best), and number of marginal bract necroses (80 cm) were counted (Little and Hills, 1972).

Table 1. Fertilizer treatments and sources of nutrients.x

<table>
<thead>
<tr>
<th>Treatment no.</th>
<th>Fertilization practice</th>
<th>NH₄NO₃</th>
<th>Ca(NO₃)₂·4H₂O</th>
<th>NH₄H₂PO₄,</th>
<th>H₂PO₄</th>
<th>KNO₃</th>
<th>KCl</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Osmocote 19N–2.6P–10K*</td>
<td>47% NO₃-N</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>30% NO₃-N – Ca</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>65% NO₃-N – Ca</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>81% NO₃-N + 903 ppm Ca</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>81% NO₃-N + 903 ppm Ca</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Medium-applied soluble fertilizers were 200-ml aliquots and contained 1120 ppm N, 489 ppm P, and 930 ppm K (Expt. 1) or 980 ppm N, 427 ppm P, and 813 ppm K (Expt. 2). These rates supplied 93% (Expt. 1) or 100% (Expt. 2) of the per-pot per-season N–P–K applied with Osmocote.

Table 2. Effect of fertilization practices on incidence of marginal bract necrosis, plant characteristics, and leaf or marginal bract tissue Ca levels of 'Gutierrez V-14 Glory' poinsettia. The means are from six plants.

<table>
<thead>
<tr>
<th>Treatment no.</th>
<th>Fertilization practice</th>
<th>Necrotic lesions &gt;1 cm</th>
<th>Bract Ca (%)</th>
<th>Leaf Ca (%)</th>
<th>Plant height (cm)</th>
<th>Plant width (cm)</th>
<th>Plant quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Osmocote 19N–2.6P–10K*</td>
<td>11 a¹</td>
<td>0.12</td>
<td>1.2 b</td>
<td>23</td>
<td>104</td>
<td>4.2</td>
</tr>
<tr>
<td>2</td>
<td>Liquid fertilizer–medium 30% NO₃-N – Ca</td>
<td>9 a</td>
<td>0.10</td>
<td>0.8 b</td>
<td>22</td>
<td>96</td>
<td>3.2</td>
</tr>
<tr>
<td>3</td>
<td>Liquid fertilizer–medium 65% NO₃-N – Ca</td>
<td>8 a</td>
<td>0.11</td>
<td>1.1 b</td>
<td>20</td>
<td>97</td>
<td>4.5</td>
</tr>
<tr>
<td>4</td>
<td>Liquid fertilizer–medium 81% NO₃-N + Ca</td>
<td>3 ab</td>
<td>0.10</td>
<td>1.4 a</td>
<td>21</td>
<td>97</td>
<td>4.3</td>
</tr>
<tr>
<td>5</td>
<td>Liquid fertilizer–foliage 10% NO₃-N + Ca</td>
<td>1 b</td>
<td>0.11 ns</td>
<td>1.5 a</td>
<td>21 ns</td>
<td>97 ns</td>
<td>4.5 ns</td>
</tr>
</tbody>
</table>

Osmocote treatment was applied as a split application, one-half incorporated at planting (12 Sept.) and one-half top-dressed (7 Nov.). Liquid fertilizers (1120 ppm N, 489 ppm P, and 930 ppm K) were applied to the soil in 200-ml aliquots weekly to simulate tube irrigation, except treatment 5, where 10% of the fertilizer was applied to the foliage to simulate injecting fertilizer into an overhead irrigation system.

Subjective quality ratings on a scale of 1 to 5, with 5 best.

Mean separation within columns by Tukey's HSD, 5% level. ns = nonsignificant. A square-root transformation was used on data for number of necrotic lesions, since variances were proportional to the means for this parameter (Little and Hills, 1972).

In a second experiment, rooted cuttings were planted on 29 Aug. and pinched on 19 Sept. Growth retardant was applied on 4 Oct. Medium was as in test 1, but amended on a cubic-meter basis with 5.9 kg of dolomite, 7.1 kg of gypsum, 3 kg of single superphosphate, and 0.9 kg of Micromax. Liquid fertilization regimes (Table 1) were initiated 6 Sept. and applied weekly for 13 weeks to the medium only. All solutions supplied the same N, P, and K per pot per season as the high NH₄-N treatment without Ca. Plant growth and quality characteristics were similar in all treatments.

In a third experiment, rooted cuttings were planted on 29 Aug. and pinched on 19 Sept. Growth retardant was applied on 4 Oct. Medium was as in test 1, but amended on a cubic-meter basis with 5.9 kg of dolomite, 7.1 kg of gypsum, 3 kg of single superphosphate, and 0.9 kg of Micromax. Liquid fertilization regimes (Table 1) were initiated 6 Sept. and applied weekly for 13 weeks to the medium only. All solutions supplied the same N, P, and K per pot per season as the high NH₄-N treatment without Ca. Plant growth and quality characteristics were similar in all treatments.

In a fourth experiment, rooted cuttings were planted on 29 Aug. and pinched on 19 Sept. Growth retardant was applied on 4 Oct. Medium was as in test 1, but amended on a cubic-meter basis with 5.9 kg of dolomite, 7.1 kg of gypsum, 3 kg of single superphosphate, and 0.9 kg of Micromax. Liquid fertilization regimes (Table 1) were initiated 6 Sept. and applied weekly for 13 weeks to the medium only. All solutions supplied the same N, P, and K per pot per season as the high NH₄-N treatment without Ca. Plant growth and quality characteristics were similar in all treatments.

In a fifth experiment, rooted cuttings were planted on 29 Aug. and pinched on 19 Sept. Growth retardant was applied on 4 Oct. Medium was as in test 1, but amended on a cubic-meter basis with 5.9 kg of dolomite, 7.1 kg of gypsum, 3 kg of single superphosphate, and 0.9 kg of Micromax. Liquid fertilization regimes (Table 1) were initiated 6 Sept. and applied weekly for 13 weeks to the medium only. All solutions supplied the same N, P, and K per pot per season as the high NH₄-N treatment without Ca. Plant growth and quality characteristics were similar in all treatments.
Table 3. Main effects of fertilization practices and weekly foliar-bract Ca sprays on the incidence of marginal bract necrosis, leaf or marginal bract Ca tissue levels, and plant characteristics of 'Guthier V-14 Glory' poinsettia. Interactive effects of fertilization practice and Ca spray treatments were not significantly different at the 5% level. Main effect means for fertilization practices are from 16 plants, and main effect means for Ca spray treatment are from 32 plants.

<table>
<thead>
<tr>
<th>Treatment no.</th>
<th>Main effects</th>
<th>Necrotic lesions</th>
<th>Bract Ca (%)</th>
<th>Leaf Ca (%)</th>
<th>Plant height (cm)</th>
<th>Plant width (cm)</th>
<th>Plant fresh wt (g)</th>
<th>No. bracts ≥14 cm</th>
<th>Plant quality rating*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Osmocote 14N–6.1P–11.6K 53% NO₃-N</td>
<td>4.2</td>
<td>0.28 a 1.84 b</td>
<td>24 a 46 a</td>
<td>192 a 33 a</td>
<td>3.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Liquid fertilizer 53% NO₃-N – Ca</td>
<td>4</td>
<td>0.29 bc 1.98 b</td>
<td>22 ab 43 ab</td>
<td>146 b 25 b</td>
<td>3.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Liquid fertilizer 53% NO₃-N + 354 ppm Ca</td>
<td>2</td>
<td>0.36 a 2.33 a</td>
<td>21 ab 42 bc</td>
<td>130 bc 24 b</td>
<td>3.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Liquid fertilizer 75% NO₃-N + 964 ppm Ca</td>
<td>2 ns</td>
<td>0.35 ab 2.49 a</td>
<td>20 b 38 c</td>
<td>112 c 21 b</td>
<td>3.6 ns</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Subjective plant quality ratings on a scale of 1 to 5, with 5 best.

**Osmocote treatment was applied as a split application, one-half incorporated in the medium at planting (29 Aug.) and one-half top-dressed (25 Oct.). Liquid fertilizers (980 ppm N, 427 ppm P, 813 ppm K) were applied directly to the medium in 200-ml aliquots weekly, and all treatments resulted in the same N, P, and K per pot for the crop cycle.

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The incidence of marginal bract necrosis and Ca sprays had no effect on plant height, but plant height did increase with the use of gypsum as a medium amendment. High root pressure results in high relative humidity and low transpiration rates. In addition, Nell and Tibbitts (1986) reported that plants produced with Osmocote would have greater numbers of lesions than plants grown with medium-applied liquid fertilizers. Nell and Barrett (1985) reported that plants produced with Osmocote had increased lesion numbers when compared to plants grown with liquid fertilization, but rates of N, P, and K were not the same in all treatments. However, from the tests reported here and others by us (unpublished data), as well as by Nell and Barrett (1985), it is obvious that fertilization rates, application methods, NH₄-N and Ca content of the fertilizer, and time of application of controlled-release or liquid fertilizer may reduce the incidence of bract necrosis, depending on environmental conditions. Thus, commercial producers should consider medium fertilization programs with ≈50% to 75% NO₃-N and supplemental medium Ca to help reduce the incidence of bract necrosis when it can be done without loss of growth or plant quality. Foliar-bract Ca sprays may be used to further reduce necrosis incidence and provide protection for those situations when conditions favor development of bract necrosis, regardless of fertilization practice.

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**Literature Cited**


Influence of Dikegulac Sprays on Shoot Emergence and Growth of Asparagus

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Additional index words. Asparagus officinalis

Abstract. Spraying 9-month-old asparagus seedlings (Asparagus officinalis L.) with dikegulac-sodium (atralin) solutions ranging from 0 to 500 ppm in 100-ppm increments increased the number of new shoots, particularly within the range of 300 to 500 ppm. The response was elicited 4 weeks after the treatment and continued thereafter over the 10 weeks, during which measurements were taken. Dikegulac did not affect the height or the fresh and dry weights of the plants for this first phase. Emergence of new shoots after the plants had been cut off was equally affected by dikegulac; 300 to 500 ppm was still the most effective. However, effectiveness was significant after 2 weeks. The height of shoots was significantly reduced by the chemical, but the fresh and dry weights were not affected. At the third phase, none of the growth characteristics, including shoot emergence, was affected by the chemical. This lack of response may be attributable to the depletion of carbohydrate reserves in the fleshy roots. Chemical name used: 2,3:4,6-bis-O-(1-methylethylidene)-a-L-Fru/o-2-hexulofuranosonic acid (dikegulac).

Progressive emergence of shoots makes the harvesting of asparagus spears time-consuming and labor-intensive, thus adding to the management cost of this crop. It also represents one of the constraints to mechanical harvesting. The year-round production of asparagus, as practiced in the tropics using the "mother-stalk" method (Yamaguchi, 1983), could also benefit from increased or simultaneous shoot emergence. Therefore, a chemical that would stimulate shoot emergence holds promise for practical use. Wittwer and Bukovac (1958) suggested the use of gibberellins (GA) to overcome positional dominance in asparagus. Tiburcio (1961), using GA drenches at 10 ppm, obtained an increase in number, diameter, weight, and length of new shoots, but, in another study, soaking the crowns in a 1000-ppm-KGA (Gibrel) solution did not increase the number of shoots per crown under field conditions (Mahotiere, 1976). Benson (1970) reported that (2-chloroethyl)phosphonic acid (ethephon) drenches were ineffective in overcoming positional dominance in asparagus. However, dipping the crowns in 750 to 1000 ppm of ethephon increased the number of shoots per crown (Mahotiere, 1976).

A more recent study indicated that dikegulac, a commercially available growth regulator effective in promoting branching in several plant species, including pecans (Malstrom and McMans, 1977), azaleas (Desilva et al., 1976; Schnall, 1978), cane cuttings of Draceana fragrans (Johnson, 1981), tomato (Frost and Kretchman, 1987), and peppers (Matta, 1984), also stimulated shoot emergence in asparagus crowns soaked in a 300-ppm solution of this chemical (Mahotiere et al., 1988).

The objective of this investigation was to determine the effects of dikegulac spray on subsequent emergence of shoots and growth of asparagus after cutting the treated ferns. Healthy and uniform 9-month-old seedlings of 'Mary Washington' asparagus were used for the experiment. They were grown in a Pro-Mix medium consisting of 60 peat-moss : 20 perlite : 20 vermiculite (by volume). The medium, with an initial pH of 6.2, was fertilized with ground limestone (CaCO₃) at 1.4-g liter⁻¹ of water, which was applied to each pot and raised the pH to 6.9 when the plants received the dikegulac treatment. The seeds were planted in a 11.5-liter pot at the rate of three seeds per pot. They were thinned to one per pot after emergence. During the growing period preceding the chemical treatment, the pots were individually fertilized once a month with a 1 g of 10N–4.35P₂O₅–8.33K₂O dissolved in 1 liter of water per pot. During the entire experiment (15 Jan. 1987 through 7 July 1988), the day and night temperatures of the greenhouse were maintained at 25 and 15C, respectively. Before spraying the seedlings, the height and number of ferns, including the emerging new shoots, were recorded. The seedlings then were sprayed individually to the drip point with the aqueous solutions of dikegulac sodium ranging from 0 to 500 ppm in 100-ppm increments. Tap water was used as a control. Each treatment was replicated 10 times with one potted seedling as an experimental unit. The pots were arranged in a randomized complete-block design. Data on cumulative new shoot emergence under the canopy were recorded daily for 10 weeks, but are reported on a biweekly basis. The final cumulative number of shoots (expressed as percent increase) is compared to the number of ferns recorded before the application of the chemical. The plants were cut at ground level, and their height and fresh and dry weights were recorded. Shoot emergence after the ferns were cut off began the second phase of the experiment. Again, cumulative data on shoot emergence were recorded daily for 10 weeks. The plants then were cut again at ground level, and their height and fresh and dry weights were recorded. This began the third and last phase, using the same method as for the second. The experiment was terminated after this phase because shoot emergence had been erratic and the plants were weak. All data were tested using regression analysis.

Dikegulac promoted shoot emergence in the range of 300 to 500 ppm, particularly after 6 weeks, with 500 ppm being the most effective (Table 1). We previously reported that dikegulic stimulated shoot emergence of soaked asparagus crowns only at 300 ppm (Mahotiere et al., 1988). The overall effect of the chemical is summarized by its effec-