# Low substrate pH can affect plant growth without inducing leaf symptomology of petunia and poinsettia

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***Abstract***

**Diagnosing plant nutritional disorders requires knowing the critical pH ranges and visual symptoms. Two experiments were conducted incorporating increasing rates of dolomitic lime to an 80% peat + 20% perlite substrate (v:v) to establish substrate pH ranges for assessing plant growth. In Experiment 1, petunia 'Single Picobella Rose Star' (RS; *Petunia milliflora*) and 'Prostrate Easy Wave Neon Rose' (NR; *Petunia multiflora*) were grown in substrates with 0, 2.97, or 5.93 kg m$^3$ of incorporated dolomitic lime. At termination, the corresponding substrate pHs were 3.3, 4.7 and 5.1 for RS and 3.4, 4.6, and 4.9 for NR, respectively, as lime rate increased. No visual symptomology was observed, but plant growth was significantly lower (59 and 42% less, respectively, for RS and NR) when comparing the lowest to the highest lime rates. In Experiment 2, poinsettia (*Euphorbia pulcherrima*) 'Premium Red' (PR) and 'Viking Red' (VR) plants were grown in substrates with 0, 4.45, or 8.90 kg m$^3$ of incorporated dolomitic lime. The corresponding substrate pHs were 3.3, 4.3 and 5.4 at termination. Plant growth was 30.4% less for PR grown at pH 3.3 than 5.4. There were no visible symptoms of iron (Fe)/manganese (Mn) toxicity at pH 3.3, and the corresponding leaf tissue values were all within the acceptable range. Therefore, smaller plant size appears to be the only observation of low pH for these two species. Growers must rely upon monitoring the substrate pH to diagnose low pH disorders, because leaf symptomology and leaf tissue analysis are not adequate indicators for accessing problems.**

**Keywords:** *Euphorbia pulcherrima*, *Petunia milliflora*, *Petunia multiflora*, toxicity

## INTRODUCTION

The management of substrate pH is important in order to optimize the availability of nutrients (Fisher, 2011; Dole and Wilkins, 2005). Optimal pH ranges are published for many floriculture species. These ranges were established after observation of iron (Fe) and manganese (Mn) toxicity when the substrate pH was too low or Fe deficiency when the substrate was too high (Whipker et al., 2011). Some species such as poinsettia (*Euphorbia pulcherrima*) are classified as not being sensitive to low substrate pH because the plants do not develop lower leaf bronzing or purplish-black spotting. The recommended substrate pH range for poinsettia is between 5.5 and 6.5 (Ecke et al., 2004). This experiment was conducted to elucidate the symptomology and growth characteristics of *Petunia* species and poinsettia subjected to low pH conditions.

## MATERIALS AND METHODS

### Experiment 1

Plugs of petunia 'Single Picobella Rose Star' (RS; *Petunia milliflora*) and 'Prostrate Easy Wave Neon Rose' (NR; *Petunia multiflora*) were transplanted on March 16, 2011 into 12.7-cm diameter (0.76-L) plastic pots. Pots were filled with a substrate composed of sphagnum peat moss amended with 20% (v/v) horticultural grade perlite (Sun Gro Horticulture, Agawam, MA). Substrate were amended with dolomitic lime ($CaMg(CO_3)_2$; Rockydale Quarries Corp.,

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Roanoke, VA) at rates of 0, 2.97, or 5.93 kg $m^3$ and a wetting agent (Aquagro 2000G™, Aquatrols®, Paulsboro, NJ) at 111 kg $m^3$ to produce a total of three lime treatments. Plants were grown at 18°C day/15°C night air temperatures in a complete randomized design with six sinlge plant replications and fertilized with 17 N-4 $P_2O_5$-17 $K_2O$ (Jack's Professional, Allentown, PA) at 150 mg $L^{-1}$ N. On May 12, plant height, measured from the pot rim to the apical meristem, diameter (widest diameter + perpendicular ÷ 2), and substrate pH and electrical conductivity (EC) data were collected on six single plant replicates. Plants were destructively harvested and the tissue was dried at 70°C for at least 1 week to determine shoot dry mass.

### Experiment 2

Rooted cutting of poinsettia 'Premium Red' (PR) and 'Viking Red' (VR) were transplanted on August 4, 2011 into 15.2-cm diameter (1.1-L) plastic pots. Pots were filled with the previously described substrate and were amended with dolomitic lime (Rockydale Quarries Corp.) at rates of 0, 4.45, or 8.90 kg $m^{-3}$ and a wetting agent (Aquagro 2000G™, Aquatrols®) at 111 kg $m^3$. Plants were grown at 18°C days/15°C night air temperatures in a complete randomized design with six single plant replications and fertilized with 17 N-4 $P_2O_5$-17 $K_2O$ (Jack's Professional) at 150 mg $L^{-1}$ N. Data were collected on six replicates for plant height, plant diameter (widest diameter + perpendicular ÷ 2), substrate pH and EC values on August 22 (WK 3), September 5 (WK 5), September 19 (WK 7), October 3 (WK 9), October 17 (WK 11), October 31 (WK 13) and November 14 (WK 15).

During the seven sampling dates, plants were destructively harvested and the leaves were initially rinsed with deionized (DI) water, then washed in a solution of 0.5 N HCl for 1 min and again rinsed with DI water. The remaining shoot tissue was harvested separately and roots were discarded. Both sets of tissue were dried at 70°C for at least 1 week, and the dry mass was weighed and recorded. After drying, fully expanded leaf tissue was ground in a sample mill (Foss Tecator Cyclotec™; Analytical Instruments, Golden Valley, MN) to pass a ≤0.5-mm sieve. Tissue analysis for N was performed with a C-H-N analyzer (model 2400 series II; PerkinElmer, Norwalk, CT) by weighing 2.5 mg of dried tissue into tin cups and placing it into the analyzer. Other nutrient concentrations were determined with inductively coupled plasma optical emission spectroscopy ((ICP-OES (model IRIS Intrepid II; Thermo Corp., Waltham, MA)). Tissue analysis was only conducted on the WK 3, 9 and 15 tissue samples. The data were analyzed using PROC MIXED and PROC GLM using SAS (version 9.2; SAS Institute, Cary, NC).

## RESULTS AND DISCUSSION

### Petunias

Substrate pH values increased as expected with the increase in lime rate. Without any amended limestone, the substrate pH values were 3.3 and 3.4, respectively, for RS and NR petunias (Table 1). The EC levels decreased as the lime rate increased. This is likely due to the higher nutrient requirements of the larger plants and was needed to support the greater growth and dry mass accumulation. No visual leaf symptoms were observed due to the low substrate pH. The main consequence of growing petunias at low pH values <3.4 was the 26 to 48% smaller sized plants as compared to the other two lime concentrations (data not shown).

Table 1. Substrate pH and electrical conductivity (EC) values and plant dry weights for 'Single Picobella Rose Star' and 'Easy Wave Neon Rose' petunias grown with 0, 2.97, or 5.39 kg $m^{-3}$ of limestone incorporated into the substrate.

| Lime rate | Single Picobella Rose Star | | | Easy Wave Neon Rose | | |
|---|---|---|---|---|---|---|
| (kg $m^{-3}$) | pH | EC (mS $cm^{-1}$)[a] | Dry weight (g) | pH | EC (mS $cm^{-1}$)[a] | Dry weight (g) |
| 0 | 3.3 | 1.64 | 2.04 | 3.4 | 1.35 | 3.70 |
| 2.97 | 4.7 | 1.25 | 3.49 | 4.6 | 1.02 | 5.18 |
| 5.39 | 5.1 | 0.75 | 4.97 | 4.9 | 0.57 | 6.38 |
| p-value[b] | ** | ** | ** | ** | ** | ** |

[a]pH and EC values based on the PourThru extraction method.
[b]Significant at 0.05, 0.01, or 0.001 for *, **, ***, respectively. NS indicates non-significance. Mean of 6 replications.

**Poinsettias**

As lime rate increased, substrate pH values increased (Figure 1). Values varied over time from 1.1 pH units with the 0 and 4.45 kg m3 lime treatments to 0.8 pH units of change for the 8.90 kg m3 treatment. Electrical conductivity values were lower at the beginning of the experiment and increased when the plants bloomed (data not shown), which corresponds to a period of less accumulation of dry mass (Figure 2). Plant height and diameter increased over time for both cultivars, with VR being a larger plant than PR (data not shown).

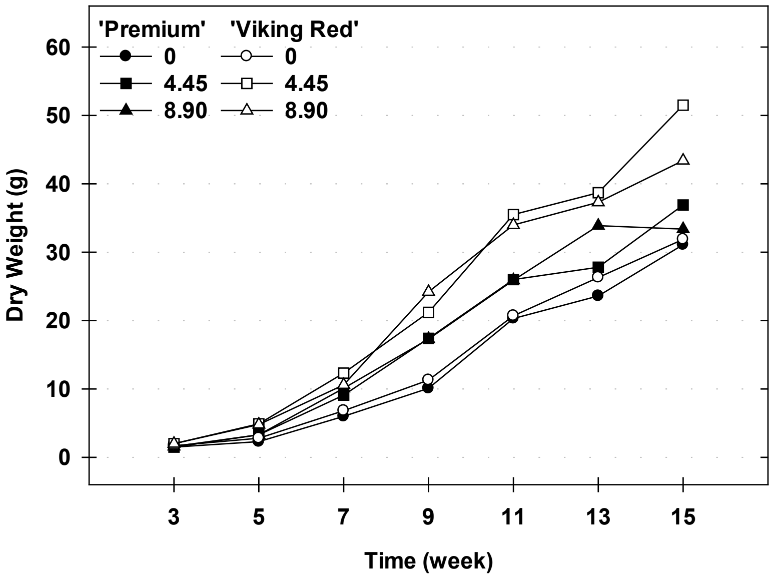


Figure 1. Substrate pH values over time for 'Premium Red' and 'Viking Red' poinsettias grown with 0, 4.45, or 8.90 kg $m^{-3}$ of limestone. Mean of 4 plants from each cultivar.

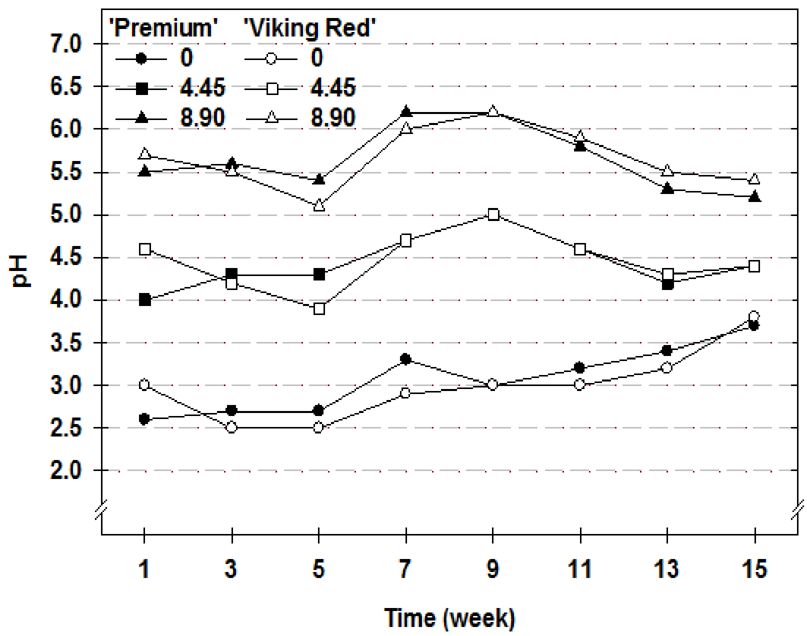


Figure 2. Plant dry weight (g) over time for 'Premium Red' and 'Viking Red' poinsettias grown with 0, 4.45, or 8.90 kg $m^{-3}$ of limestone. Mean of 4 plants from each cultivar.

For both cultivars, no visual leaf symptoms due to the low pH substrate were observed. The primary difference was that at low substrate pHs, plant growth was less. For species that exhibit leaf symptomology such as geraniums (*Pelargonium* × *hortorum*), ageratum (*Ageratum houstonianum*), begonia (*Begonia* × *semperflorens-cultorum*), and streptocarpus (*Streptocarpus* sp.), this lower leaf discoloration occurs when toxic levels of micro-nutrients accumulate. Tissue analysis is a tool that is used to diagnose toxicities by determining if micro-nutrients levels are excessive. As an overall trend, the concentrations of Fe (Figure 3a), Mn (Figure 3b) and boron (B) (Figure 3c) were higher in the plants grown at the lowest substrate pH without lime (0 kg $m^{-3}$). The upper acceptable ranges recommended by Ecke et al. (2004) include 300 mg $kg^{-1}$ for Fe and Mn and 75 mg $kg^{-1}$ for B. High levels of Mn are considered to be above 650 and 100 mg $kg^{-1}$ for B. The highest leaf tissue concentrations for poinsettias grown in this study were 212.7 mg $kg^{-1}$ for Fe, 158.1 mg $kg^{-1}$ for Mn, and 42.4 mg $kg^{-1}$ for B. All these values are within the recommended ranges.

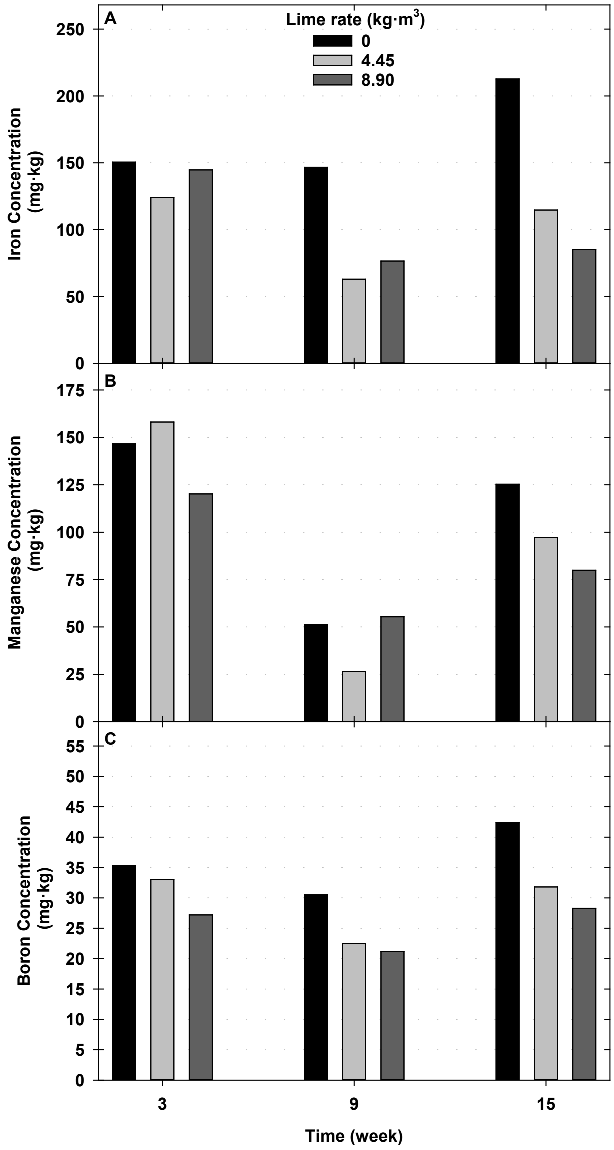


Figure 3. Tissue iron (Fe) (a), manganese (b), and boron (c) concentrations in poinsettias grown with 0, 4.45, or 8.90 kg $m^{-3}$ of limestone. Mean of 12 plants from both cultivars.

## CONCLUSIONS

In these experiments, toxicity symptoms did not develop with petunias or poinsettia grown without lime, which resulted in substrate pH values below 4.0. Less dry mass was the primary result of growing these plants at lower substrate pHs. Leaf tissue concentrations of Fe, Mn, and B were within the acceptable range for poinsettia. Based on these results, the reason poinsettia did not exhibit lower leaf symptomology is because micro-nutrient levels did not accumulate to toxic levels in the plant. Furthermore, utilizing leaf tissue analysis to help diagnose low substrate pH conditions is not a tool available for plants such as poinsettia because of this lack of micro-nutrient accumulation.

## ACKNOWLEDGEMENTS

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