Phosphorus Deficiency in *Pelargonium*: Effects on Nitrate and Ammonium Uptake and Acidity Generation

Geraniums are the highest valued plant of the 2.5 billion dollar bedding plant industry. During the 1980's, geranium producers reported sporadic and unexplained declines in substrate pH. One cause of this phenomenon may be phosphorus (P) deficiency, as growers often rely on alkaline fertilizers, in which P is low or absent, to offset pH declines. The progression of P-stress from rhizosphere acidification, uptake of nitrate (NO_3-) and ammonium (NH_4^+), and cation to anion uptake ratios were evaluated to help address the role of P-stress in sudden pH decline (SPD).

Unrooted geranium (*Pelargonium x hortorum* Bailey 'Designer Dark Red') cuttings were grown in hydroponic solutions either with or without P at two different temperature regimes, 22/18°C and 26/22°C. At specific times [3, 11, and 19 days after transplanting (DAT)] selected plants were moved to identical solutions containing the stable isotope ^{15}N as either 15 A % $^{15}NH_4^+$ or $^{15}NO_3^-$ for a 24 hour time period. Root and shoot tissue samples were analyzed for nutrient concentrations via elemental N analysis, ratio mass spectroscopy, and inductively-coupled plasma optical emission spectroscopy. Acidification potential was measured by the amount of titrating base required to maintain the solution pH at 5.8.

The amounts of base used to maintain a pH of 5.8 were different in the +P and –P treatments at both temperatures. At 22/18°C, plants grown without P required 2.4 times the amount of base than plants with sufficient P, and there was a similar, but less dramatic effect at 26/22°C. Uptake of $^{15}NH_4^+$ or $^{15}NO_3^-$ was calculated from the ^{15}N contents in roots and shoots after 24 h of exposure to the specific ^{15}N treatments. For the three sample dates, the mean root uptake of $^{15}NH_4^+$ was lower in plants without P than in control plants (Table 1). Uptake of $^{15}NO_3^-$ also was lower in P-limited plants than in controls (Table 1).

Table 1. Main effects of P treatment on $^{15}NH_4^+$ and $^{15}NO_3^-$ uptake per gram root dry weight over a 24 hour period, and the NH_4^+ and NO_3^- uptake ratio.

	Whole Plant ^{15}N Uptake (mg $^{15}N \cdot g^{-1}$ root dry weight)		
P Treatment	$^{15}NH_4^+$	$^{15}NO_3^-$	NH_4^+ to NO_3^- Uptake Ratio
Plus P	1.64	5.15	0.323
Minus P	1.19	3.31	0.394
Significance	*	**	*
Difference in ^{15}N uptake	0.45	1.84	

* and ** Significant at $P = 0.05$ and 0.01, respectively.

Tissue nutrient profiles showed that the NO_3^- uptake inhibition was accompanied by an increase in the cation to anion uptake ratio (Figure 1). It has previously been determined that cation uptake is linked with H^+ efflux and anion uptake with H^+ influx. Thus, a decline in anion uptake greater than that in cation uptake, like that occurring here with P-stressed geranium, results in increased H^+ release from the nutrient absorbing root cells.

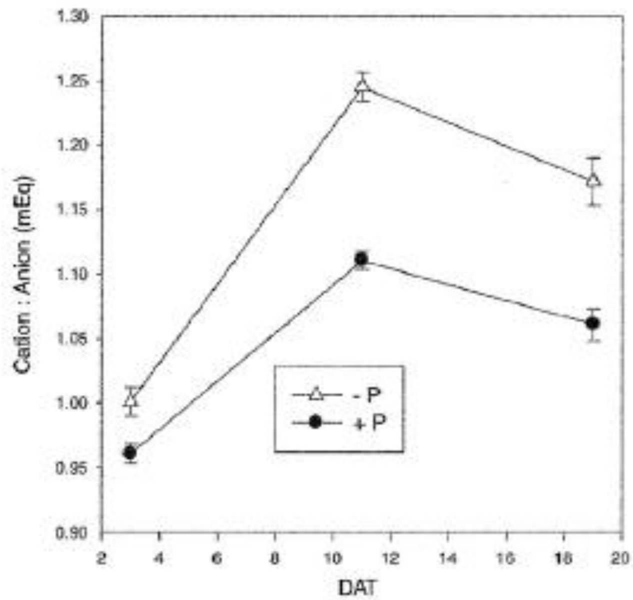

Figure 1. Uptake ratio of cations to anions in plants grown with or without P 3, 11, and 19 days after transplanting (DAT).

Interestingly, rhizosphere acidity increased at the higher temperatures, even though plant growth and cation and anion balance was not statistically different than at lower temperatures, which indicates additional factors. Additional acidification could be associated with higher root respiration and increased release of CO_2. Overall, the changes in cation and anion uptake and the associated increase in H+ extrusion under P-stress can contribute to SPD in geranium culture systems.

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For more information, contact: Thomas Rufty, tom_rufty@ncsu.edu, Department of Crop Science, North Carolina State University, Raleigh, NC, 27695

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