



FERTILITY MANAGEMENT FOR GERANIUMS

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Geraniums require an adequate supply of the essential nutrients and a slightly acidic pH. This leaflet covers some of the basic considerations for fertilizing zonal, ivy, and regal geraniums. Optimal pH, electrical conductivity (EC), and nutrient levels for the substrate are listed in Table 1. These values are based on the saturated paste extract method. Differences are listed for zonal, ivy, and regal geraniums. More specifics for each element as to the function, deficiency and toxicities, and fertilization strategies are covered below. The fertilization and EC strategies are based on an irrigation practice with 20% leaching. Fertilization levels would be

25% to 50% lower with a subirrigation or reduced leaching irrigation program in order to achieve similar substrate nutrient levels as with a 20% leaching program. Nutrient deficiency and toxicity symptoms for zonal geraniums are listed in Table 2 and Table 3 lists leaf tissue analysis standards for zonal, seed, ivy, and regal geraniums.

pH: The optimal pH varies by the type of geranium and substrate used. For zonal geraniums, the range for a soilless substrate is 5.8 to 6.2 and for a soil based medium is 6.0 to 6.5. The optimal range is up to 0.3 units lower for ivy and regal geraniums. If modifications are required,

the pH can be lowered with an acid-based fertilizer or acid injection. The pH can be increased with dolomitic limestone or hydrated lime.

Electrical Conductivity (EC): The optimal EC range is 1.5 to 2.5 mS/cm for zonal and regal geraniums. Slightly lower levels are required by ivy geraniums. To lower EC levels, growers can apply a clear water leach or, more optimally, simply decrease their fertilization rate. If EC levels are low, increasing the fertilization rate will increase the substrate EC.

Nitrogen (N): The function of nitrogen is in the synthesis of amino acids,

Table 1. Optimal substrate nutrient levels for geraniums.

Test	Units	Optimal range ^a		
		Zonal geranium	Ivy geranium	Regal geranium
pH		5.8 to 6.3	5.5 to 6.0	5.5 to 6.0
EC	mS/cm	1.5 to 2.5	1.0 to 2.0	1.5 to 2.5
N ^b	ppm	200 to 250	200 to 250	150 to 250
P	ppm	5 to 19	5 to 19	5 to 19
K	ppm	150 to 250	150 to 250	150 to 250
Ca	ppm	50 to 100	50 to 100	50 to 100
Mg	ppm	25 to 50	25 to 50	25 to 50

^aRanges based on the saturated paste extract method.

^bNitrate-nitrogen should comprise ≥75% of the total N, with the remainder being ammoniacal-N or urea-N.

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Element	Deficiency symptoms	Toxicity symptoms
Nitrogen (N)	Slow growth, stunting, or with advanced conditions, lower leaf chlorosis (yellowing)	Reduced plant growth and delayed flowering. Ammoniacal-N toxicity is expressed as a curling of the older leaves, leaf chlorosis and necrosis
Phosphorus (P)	Stunting of plant growth with the leaves turning dark green. Under advanced P deficiency conditions, the lower leaves will become reddish-purple and ultimately necrotic (die)	Reduced plant growth and high P levels can induce deficiencies of Fe, Zn, Cu, and Mn
Potassium (K)	Necrosis (death) of lower leaf margins and plants develop weak stems and stalks	Excess levels of K can reduce the uptake of Ca, Mg, Mn, and Zn
Calcium (Ca)	Expressed as death (blackening) of growing points of terminal buds and roots	Excess levels of Ca can reduce the uptake of K, Mg, and B
Magnesium (Mg)	Interveinal chlorosis of older leaves and the leaves may have an upward curl on the edges	Excess levels of Mg can reduce the uptake of Ca
Iron (Fe)	Interveinal chlorosis of the younger leaves, progressing to tip dieback under severe conditions. Deficiencies occur when the substrate has a high pH, root death has occurred, or when there are excessive levels of P, Mn, or Cu	Chlorotic and necrotic speckling of the lower leaves. Excess levels of Fe can reduce the uptake of Mn. Toxicity symptoms mainly occur when the substrate pH is too acidic

proteins, enzymes, and nucleic acids. Deficiency symptoms are exhibited as slow growth, stunting, or with advanced conditions, lower leaf chlorosis (yellowing) and leaf abscission in some plants. Excess levels of N will result in reduced plant growth and delayed flowering. Geraniums are susceptible to ammoniacal-N ($\text{NH}_4\text{-N}$) toxicity which is expressed as a curling of the older leaves, leaf chlorosis, or necrosis. Ammoniacal-N toxicity can be avoided by supply >75% of N in the nitrate (NO_3^-) form. N should be supplied at the rate of 200 to 250 ppm for zonal and ivy geraniums. Regal geraniums require less N. Excellent sources for N would be calcium nitrate, potassium nitrate, ammonium nitrate, 20-10-20, or 15-5-25.

Phosphorus (P): The function of phosphorus in plants is in energy transfer (ADP), nucleic acids, enzymes, and membrane structure. It also plays an important role in root and floral development and stimulates rapid plant growth. Deficiency symptoms are first expressed as extensive stunting with the leaves turning dark green. Under advanced P deficiency conditions the lower leaves will become reddish-purple, then chlorotic, and ultimately necrotic. Excessive P will reduced plant growth and can induce deficiencies of Fe, Zn, Cu, and Mn. Supply P at the rate of 5 to 20 ppm. P promotes stem growth, therefore limit applications to avoid stretch. P can be supplied as: 1) a preplant amendment of triple superphosphate incorporated into the

Table 3. Leaf tissue analysis standards for geraniums.

Element	Zonal geranium	Seed geranium	Ivy geranium	Regal geranium
Nitrogen (%)	3.8 to 4.4	3.7 to 4.8	3.4 to 4.4	3.0 to 3.2
Phosphorus (%)	0.3 to 0.5	0.3 to 0.6	0.4 to 0.7	0.3 to 0.6
Potassium (%)	2.6 to 3.5	3.3 to 3.9	2.8 to 4.7	1.1 to 3.1
Calcium (%)	1.4 to 2.0	1.2 to 2.1	0.9 to 1.4	1.2 to 2.6
Magnesium (%)	0.2 to 0.4	0.2 to 0.4	0.2 to 0.6	0.3 to 0.9
Iron (ppm)	110 to 580	120 to 340	115 to 270	120 to 225
Manganese (ppm)	270 to 325	110 to 285	40 to 175	115 to 475
Zinc (ppm)	50 to 55	35 to 60	10 to 45	35 to 50
Copper (ppm)	5 to 15	5 to 15	5 to 15	5 to 10
Boron (ppm)	40 to 50	35 to 60	30 to 280	15 to 45

From Biamonte et al.

substrate mix or 2) as a constant liquid feed via phosphoric acid, monopotassium phosphate, ammonium phosphate, 20-10-20, or 15-5-25. Remember when calculating P fertilization rates, the numbers on the fertilizer bag are expressed as percent of P_2O_5 . Therefore multiply the bag number by 0.437 for the percentage of P.

Potassium (K): Potassium is involved as a metabolism catalyst, for stomata function, and disease resistance. Deficiency symptoms appear as necrosis of lower leaf margins and plants develop weak stems and stalks. Excess levels of K can reduce the uptake of Ca, Mg, Mn, NH_4-N , and Zn. K should be applied at the rate of 150 to 250 ppm. To insure that K does not interfere with Ca and Mg uptake, a K : Ca : Mg fertilizer ratio of 4 : 2 : 1 should be used (similar to poinsettias). Excellent sources for K are potassium nitrate, 20-10-20, or 15-5-25. Remember when calculating K fertilization rates, the numbers on the fertilizer bag are expressed as a percent of K_2O . Therefore multiply the bag number by 0.83 for the percentage of K.

Calcium (Ca): Calcium is a major constituent of cell walls. Deficiency symptoms are expressed as death (blackening) of growing points of

terminal buds and roots. Ca is a non-mobile element and uptake is by the root tips. Excess levels of Ca can reduce the uptake of K, Mg, and B. A fertilization rate of 50 to 100 ppm Ca should be used, remembering to maintain the K : Ca : Mg fertilizer ratio of 4 : 2 : 1. Ca can be supplied from your irrigation water (if adequate levels exist), dolomitic limestone, or calcium nitrate. Remember that Ca uptake into the plant and transportation within the plant is through the water flow, so promoting good root growth so water uptake can occur and good shoot growth that aids in transpiration will assist in Ca uptake.

Magnesium (Mg): Magnesium is an important element in the chlorophyll molecule and in enzyme activation. Deficiency symptoms appear as interveinal chlorosis of older leaves and the leaves may have an upward curl. Excess levels of Mg can reduce the uptake of Ca. Mg fertilization rates of 25 to 50 ppm should be adequate, remembering to maintain the K : Ca : Mg fertilizer ratio of 4 : 2 : 1. Sources of Mg are dolomitic limestone, Mg in water supply (if adequate levels exist), and magnesium sulfate (Epsom salts). To correct a Mg deficiency, magnesium sulfate can be mix at the rate of 1

pound in 100 gallons of water and applied as a drench. Do not mix magnesium sulfate with other fertilizers. To prevent Mg deficiency, magnesium sulfate can be applied monthly.

Iron (Fe): Like magnesium, iron also plays a role in the chlorophyll molecule. Deficiency symptoms appear as an interveinal chlorosis of the younger leaves, progressing to tip dieback under severe conditions. Deficiencies occur when the substrate has a high pH, root death has occurred, or when there are excessive levels of P, Mn, or Cu. Excess levels of Fe can reduce the uptake of Mn. Toxicity symptoms occur when the substrate pH is too acidic. Toxicity symptoms frequently appear with seed geraniums at a pH <5.5. Symptoms appear as chlorotic and necrotic speckling of lower leaves. Vetanovetz and Knaus found Fe toxicity occurs more readily when the pH is less than 6.0, when Fe is 1.0 ppm or above (based on a saturated paste extract), and when the Fe-to-Mn ratio is >3:1. Supply Fe in your postplant fertilization program or by preplant incorporation into the substrate, but do not provide excessive levels. Iron can also be supplied from iron chelates, ferrous sulfate, or fritted iron. Recommended rates and considerations for correcting iron deficiencies are contained in Hort. Info. Lflt. #553, Managing Micronutrients in the Greenhouse. Fe toxicity or deficiency can be avoided by providing adequate amounts of Fe and maintaining a substrate pH between 5.8 and 6.5.

Example Fertilizer Regime: The following example recipe can be used to meet the nutritional

requirements of zonal geraniums. Mix together the following amounts per gallon of concentrate for a 1:100 injector: 9 oz calcium nitrate + 7 oz potassium nitrate + 6 oz Excel® 15-5-15 Cal-Mg. Also provide monthly applications of magnesium sulfate at 1 pound per 100 gallons of water. Using the above recipe would provide (in ppm): 214 NO₃-N, 21 NH₄-N, 10 P, 246 K, 138 Ca, 9 Mg (value does not account for Mg supplied from the monthly MgSO₄ applications), and micronutrients. Remember to conduct routine substrate tests to monitor nutrient levels.

Water Quality: Peat-based media are more susceptible to chemical property changes than soil-based media. Well water which is high in alkalinity will gradually cause the pH to become basic. At pH's above 7.0, iron availability decreases, resulting in iron deficiency (iron chlorosis). Conduct a water test to determine the pH and alkalinity of your irrigation water and consider acid injection if needed.

For Further Reading:

- Bethke, C. 1993. Growing media, p. 3-23. In: J. White (ed.). Geraniums IV. Ball Publ., West Chicago, IL
- Biamonte, R., J. Holcomb, and J. White. 1993. Fertilization, p. 39-54. In: J. White (ed.). Geraniums IV. Ball Publ., West Chicago, IL
- Oglevee geranium culture guide. 1995. Oglevee Inc.
- Vetanovetz, R. and J. Knaus. 1989. Iron toxicity: what you should know. Benchmarks Vol. 4, No. S. Grace-Sierra Hort. Products Co.

Recommendations for the use of chemicals are included in this publication as a convenience to the reader. The use of brand names and any mention or listing of commercial products or services in this publication does not imply endorsement by the North Carolina Cooperative Extension Service nor discrimination against similar products or services not mentioned. Individuals who use chemicals are responsible for ensuring that the intended use complies with current regulations and conforms to the product label. Be sure to obtain current information about usage and examine a current product label before applying any chemical. For assistance, contact an agent of the North Carolina Cooperative Extension Service in your county.