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,
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 (NH₄⁻N) toxicity which is expressed as a curling of the older leaves, leaf chlorosis and necrosis. Ammoniacal-N toxicity can be avoided by supply >75% of N in the nitrate (NO₃⁻) 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 and ultimately necrotic. 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.

---

<table>
<thead>
<tr>
<th>Element</th>
<th>Deficiency symptoms</th>
<th>Toxicity symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (N)</td>
<td>Slow growth, stunting, or with advanced conditions, lower leaf chlorosis (yellowing)</td>
<td>Reduced plant growth and delayed flowering. Ammoniacal-N toxicity is expressed as a curling of the older leaves, leaf chlorosis and necrosis</td>
</tr>
<tr>
<td>Phosphorus (P)</td>
<td>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)</td>
<td>Reduced plant growth and high P levels can induce deficiencies of Fe, Zn, Cu, and Mn</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>Necrosis (death) of lower leaf margins and plants develop weak stems and stalks</td>
<td>Excess levels of K can reduce the uptake of Ca, Mg, Mn, and Zn</td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td>Expressed as death (blackening) of growing points of terminal buds and roots</td>
<td>Excess levels of Ca can reduce the uptake of K, Mg, and B</td>
</tr>
<tr>
<td>Magnesium (Mg)</td>
<td>Intervernal chlorosis of older leaves and the leaves may have an upward curl on the edges</td>
<td>Excess levels of Mg can reduce the uptake of Ca</td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>Intervernal 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</td>
<td>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</td>
</tr>
</tbody>
</table>
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$_2$O. 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

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

From Biamonte et al.

| Table 3. Leaf tissue analysis standards for geraniums.
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. Ventanovetz 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. Lftt. #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:**
White (ed.). Geraniums IV. Ball Publ., West
Chicago, IL
Fertilization, p. 39-54. In: J. White (ed.).
Geraniums IV. Ball Publ., West Chicago, IL
Oglevee geranium culture guide. 1995. Oglevee
Inc.
what you should know. Benchmarks Vol. 4,
No. S. Grace-Sierra Hort. Products Co.