

Organize Crops by Nutrition

This easy system shows you how to make sure all of your crops are matched to their optimum pH conditions.

By Paul Fisher and William Argo

You could receive a perfectly healthy liner or plug, but without correct fertilization crop quality (and profit) will quickly go downhill.

Because the wide range of plant species we grow differ in nutritional needs it is often difficult to grow multiple crops with a one-size-fits-all fertilizer program. Our research has shown that it is helpful to understand varietal differences and to separate crops during production according to these needs.

DEFINING THE GROUPS

Iron and manganese are more soluble and available for uptake by plant roots at low media pH. When pH is below 6, some "iron-inefficient" plants such as marigold, seed and zonal geranium, and New Guinea impatiens are able to take up so much iron or manganese that toxicity symptoms occur. Iron-inefficient plants such as geraniums have strategies to increase iron solubility and uptake, for example by exuding acid to drop pH around the root zone, increasing root

enzyme activity, or exuding chelating agents through the roots.

"Iron-inefficient" plants, for example petunia and calibrachoa, lack iron efficiency strategies. These species often show iron deficiency symptoms when media pH is above 6.4. You may be familiar with petunia or calibrachoa having chlorotic new growth. In most cases, plants with these symptoms do not need more nitrogen, potassium or phosphorus. Rather, they are lacking iron because the high pH means that iron is insoluble in the growing medium and therefore unavailable for uptake by roots.

We have found it helpful to organize plants into three groups that vary in their efficiency at taking up micronutrients. These groups range from the Geranium Group (iron-efficient) through an intermediate General Group to the iron-inefficient Petunia Group. The three nutritional groups alert you to which problems are likely to arise with each species and can help you simplify fertilizing multiple species.

At the University of New Hampshire, we have run trials to help separate plants into these groups. Combined with industry experience, those results are summarized in Figure 1, page 58.

Our list of species is incomplete, so you might want to mimic our experiment to separate other varieties into the three groups. We grew plants in a peat/perlite (70 percent/30 percent by volume) medium at pH 5, 6 and 7 using different lime incorporation rates. In addition, we drenched plants at the high lime treatment with 45 ppm of iron from iron-EDDHA (0.1 oz. per gal.). If you only have a commercial blended medium available, a high pH treatment could be created by repeatedly drenching media with flowable lime (1-gal. flowable lime diluted at 1:50) until the pH increases to 7. A low pH



Top: Iron/manganese toxicity symptoms in older leaves of seed geranium (left) and African marigold (right) grown at pH 5. Bottom: Iron deficiency symptoms in petunia (left) and calibrachoa (right) grown at pH 7. (Photos courtesy of Paul Fisher)



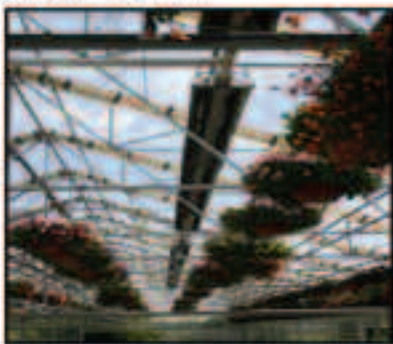
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treatment could also be created by repeatedly drenching media with ferrous iron sulfate at 2 lb. per 100 gal. until the pH drops to 5.

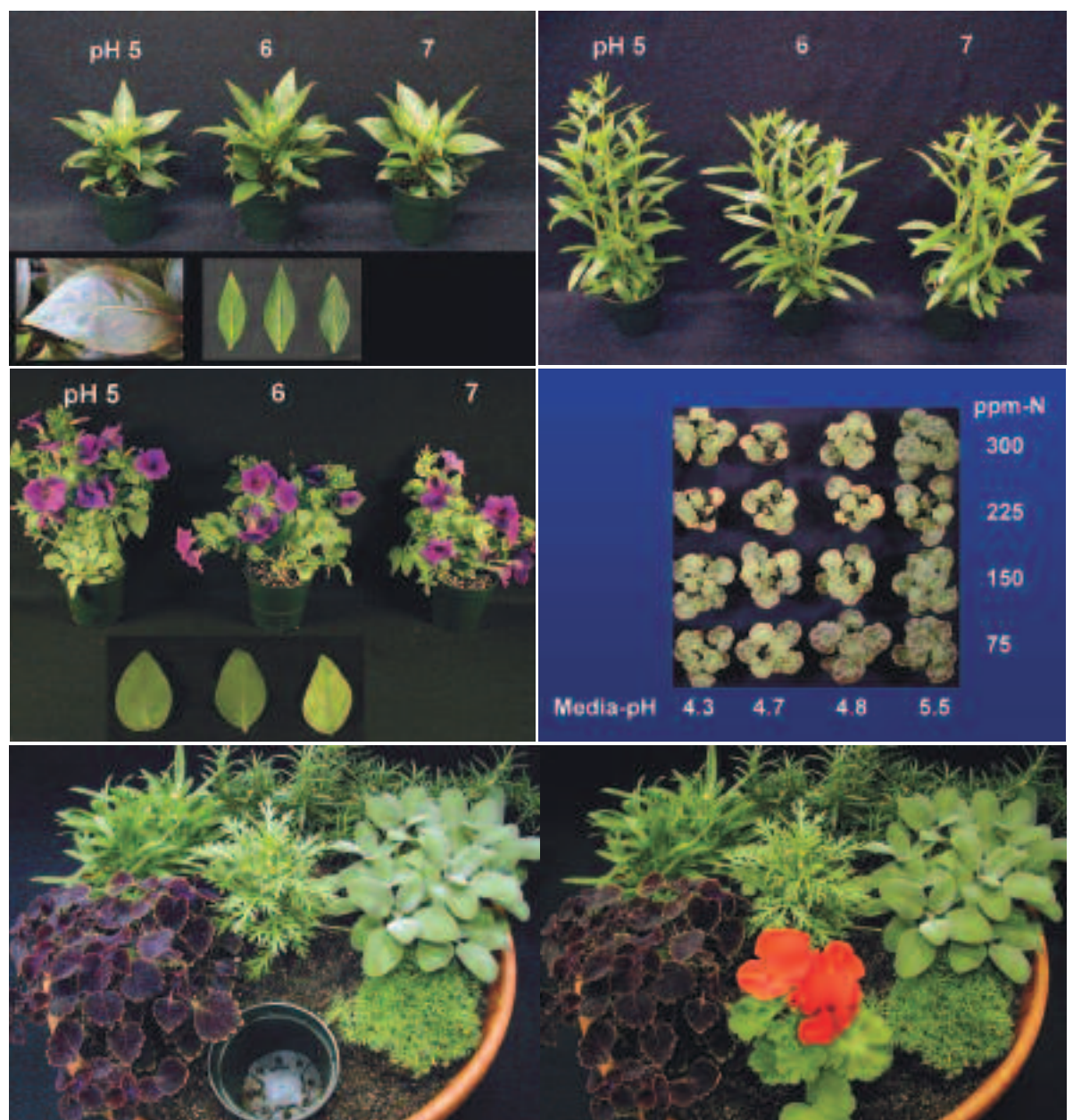
We used a SPAD chlorophyll meter (available at Spectrum Technologies) to evaluate leaf color, but you could achieve a similar result by a visual green color scale. We also measured plant growth and checked the plants for signs of micronutrient toxicity at low pH or following the iron drench. Micronutrient toxicity typically appears as small necrotic (dead) leaf spots. Plants that show iron deficiency symptoms and reduced growth at high pH tend to be categorized in the Petunia Group. Species with increased growth at high pH or micronutrient toxicity either at low pH or following the iron drench

are in the Geranium Group. Less pH or micronutrient-sensitive varieties are in the General Group.

MANAGING MULTIPLE CROPS

If you are able to manage crops separately, then Figure 2, page 59, shows ideal conditions to grow each group and techniques for correcting pH- and iron-related problems. This is a summary of fertilizer and corrective actions, and trialing under your conditions is essential before applying these methods on a commercial scale.

Train staff to recognize likely problems with each group of plants — micronutrient deficiency at high pH for the iron-inefficient Petunia Group and toxicity for the iron-efficient Geranium Group at low pH. ▶



Top left: New Guinea impatiens is in the Geranium Group. These plants will often grow more vigorously when grown at a media pH above 6.0 and are susceptible to micronutrient toxicity at pH below 6.0. Supplemental iron drenches are also likely to cause toxicity (shown as leaf spotting on the left of the photo). Other crops in this group, notably marigolds and seed or zonal geraniums, are even more sensitive to low pH-related problems than New Guinea impatiens. **Top right:** Angelonia is in the General Group and is fairly insensitive to media pH-related problems. These plants can be grown at a moderate pH of 5.6-6.4 without problems. **Middle left:** Supertunia is in the Petunia Group and is prone to iron deficiency when grown with a media pH above 6.4. These plants should be grown at a low pH of 5.4-6.2 to increase iron solubility. If the media pH is high they will respond positively to a supplemental iron drench. **Middle right:** 'Ringo Scarlet' geranium was grown for three weeks at four media pH levels achieved with different lime rates. A peat-lite fertilizer that included micronutrients was applied at four concentrations (shown as ppm N) with each irrigation. The chart shows that iron/manganese toxicity symptoms worsened as media pH decreased and concentration of a complete fertilizer increased. (Photo courtesy of Brandon Smith) **Bottom:** One option is to combine plants from different nutritional groups near the point of sale.

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Maintain a moderate media pH of 6.0-6.2 when growing a range of species in the same container (e.g., a combination basket or pot) or using the same fertilizer injector and medium.

When planting combination baskets, do not try to grow every possible mix of species. For example, it may not be the best idea to mix red seed geraniums (very susceptible to iron toxicity) with white calibrachoa (very susceptible to iron deficiency). Ask yourself, "Do you have to have a geranium and a calibrachoa, or do you need a red upright plant and a white trailing plant?" There are many species that fit your plant color or form requirements without having conflicting pH requirements.

If you must have specific combinations that



A challenging combination for nutrient management: petunia, marigold and geranium.

Figure 1. Features of Geranium, General and Petunia Groups

FEATURE	GERANIUM GROUP	GENERAL GROUP	PETUNIA GROUP
Chlorosis occurs in new tissue at high pH (e.g., 6.8).	Generally no. Chlorosis may occur above pH 6.8 if iron in fertilizer is low (e.g., 0.5 ppm or less with each irrigation).	Varies between cultivars and species. Somewhat prone to chlorosis when media pH is above 6.4.	Very common problem. Highly sensitive to pH above 6.4.
Stunting occurs at high pH (e.g., 6.8).	Generally no, except when overall fertilizer is low. Plants may be more vigorous at a moderately high range (6.0-6.6) compared with pH below 6.0.	Most vigorous growth usually occurs at a moderate pH range (5.6-6.4). Some species tolerate a wide pH range (e.g., angelonia and heuchera). Stunting will occur if grown at pH 7 for a prolonged period.	Yes, high pH can cause severe stunting, chlorosis and ultimately death of growing points. Best growth in the range of 5.4-6.2.
Necrosis (dead spots and leaf margins) occurs at pH 5 in response to iron/manganese toxicity.	Yes, a common problem, especially in marigold and geranium.	Not usually unless iron concentration is high (e.g., greater than 3 ppm with each irrigation).	Rare, unless there is a very high iron concentration (e.g., 5-10 ppm with each irrigation).
An iron drench applied when plants are grown at pH 6.8 will increase chlorophyll level and growth.	Only if iron is severely deficient, which is not common unless fertilizer levels are low and pH is high for an extended period. Excess iron may cause stunting.	If chlorotic symptoms are present and plants are iron-deficient, then an iron drench will green up plants and increase vigor.	Iron deficiency usually occurs at high pH. An iron drench, therefore, often causes a dramatic increase in growth.
Phytotoxicity occurs when iron drench is applied to plants grown at pH 6.8.	Yes, highly likely. Never apply more than 5 ppm iron with a single application, even when plants are highly iron-deficient. Always test these plants before drenching the entire crop.	Toxicity can occur on certain varieties (e.g., heuchera, osteospermum, tiarella and verbena). Test on a small group of plants before applying. 20 ppm iron is recommended as a corrective drench.	Not usually, but always test a small group of plants before applying to entire crop. 20 ppm iron is recommended as a corrective drench.
Example crops.	Ajuga 'Caitlin's Giant', lisianthus, marigold, New Guinea impatiens, seed and zonal geraniums.	Angelonia, begonia, bidens, bracteantha 'Golden Beauty', chrysanthemum, fuchsia, helichrysum, heliotrope, heuchera, impatiens, ivy geranium, osteospermum, poinsettia, <i>Scirpus cernuus</i> , tiarella, tomato, vendidum, verbena (broad-leafed varieties), <i>vinca major</i> .	Argyranthemum, azalea, basil, bacopa, brachycome, calibrachoa, dianthus, diascia, lantana, nemesia, pansy/viola, <i>Pennisetum mesasiacum</i> , petunia, rhododendron, sanvitalia, scaevola, snapdragon, torenia, verbena (fine-leafed varieties).

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do not grow well together, grow plants for combination baskets or pots in separate 4-inch pots, and combine in the final container two weeks

before sale. This minimizes nutrition problems and allows plants to be grown under several different fertilizer regimes. The Geranium Group

can be more susceptible to toxicity early in production when it is actively growing and fertilizer applications are more frequent or heavier. ▶

Figure 2. Fertilizer management and corrective actions for each pH group.

	GERANIUM GROUP	GENERAL GROUP	PETUNIA GROUP
Suggested iron concentration in water-soluble fertilizer for constant fertigation.	0.5-1.0 ppm iron sulfate or chelate	0.75-1.5 ppm iron chelate	1-3 ppm iron chelate. If using the lower level of iron, pH must be 5.4-6.0. Otherwise, use a higher iron rate.
Ideal pH range.	6.0-6.6	5.6-6.4	5.4-6.2
Suggested strategy for correcting a high media pH (above the ideal range, and only if iron deficiency is observed).	Only take action if deficiency symptoms are present, and use ammonium fertilizer (see below) as the main tool.	<ul style="list-style-type: none"> • Change to an acid-reaction (high ammonium). Read the fertilizer bag to check if the fertilizer has potential acidity and more than 25 percent of nitrogen is in the ammonium form. 9-45-15 and 21-7-7 are very acidic fertilizers with 100 percent of nitrogen as ammonium. 20-10-20 is a mildly acidic fertilizer (39 percent ammonium). Beware of excess growth. Not advisable in cold, wet conditions because there is potential for ammonium toxicity and because there is less effect on pH at low temperatures. • If alkalinity is above 100 ppm CaCO₃, acidify irrigation water to zero alkalinity (approximately pH 4.5), and continue acidification until media pH drops over time. • Acid drenches with iron sulfate (2 lb. per 100 gal.) or a mineral acid (at water pH 1.5) often lead to phytotoxicity and require repeated applications. These acid drenches are therefore generally not recommended without guidance from a fertilizer expert. 	
Suggested strategy for correcting iron deficiency.	<ul style="list-style-type: none"> • Send in a soil and tissue analysis to a lab — iron deficiency is not usually a problem unless pH is very high (above 6.8) and/or fertilizer level is very low. • Check that the injector is working and that media EC is in the normal range. If media EC is low, raise fertilizer concentration to 200-300 ppm nitrogen (avoid overcompensating with excess fertilizer) until media EC returns to normal. • Check root health, and apply a fungicide or fungus gnat pesticide if needed. • If deficiency symptoms are severe and tissue analysis shows low iron, drench with 5-10 ppm iron (iron-EDDHA at 1.1-2.2 oz. per 100 gal. or iron-DTPA at 0.67-1.3 oz. per 100 gal.). Always test a small batch first and check for toxicity symptoms after seven days before applying to entire crop. Do not reapply iron. 	<ul style="list-style-type: none"> • Send in a soil and tissue analysis to a lab. • Check that the injector is working and that media EC is in the normal range. If EC is low in the media, raise fertilizer concentration to 200-300 ppm nitrogen until EC returns to normal. A one-time application at 400 ppm nitrogen can also be effective. • Check root health, and apply a fungicide or fungus gnat pesticide if needed. • If pH is high (higher than 6.4) make a test application of iron to a few plants (see below) immediately to evaluate phytotoxicity and response while you wait for soil and tissue analysis results. • If iron level is confirmed as low in tissue (below 100 ppm) consider an iron drench. Recommended drench rates are 10-20 ppm iron (iron-EDDHA at 2.2-4.5 oz. per 100 gal. or iron-DTPA at 1.3-2.7 oz. per 100 gal.). • With all iron drenches apply to the soil and wash foliage. Test with a small batch first and check for toxicity symptoms after seven days before applying to entire crop. Reapply at 10-20 ppm of iron if plants have not greened up after one week. 	

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Figure 2 continued

	GERANIUM GROUP	GENERAL GROUP	PETUNIA GROUP
Suggested strategy for low pH and correcting iron/manganese toxicity.	<p>Toxicity is likely if pH is lower than 6.0.</p> <ul style="list-style-type: none"> • Switch to a nitrate based fertilizer (e.g., 13-2-13, 14-0-14). • Iron should not be more than 1 ppm in the nutrient solution. • Drench with flowable lime, 1 gal.:100 gal. dilution or potassium bicarbonate at 2 lb. per 100 gal. Immediately rinse foliage to remove lime residue. Reapply after five days if pH has not climbed above 6.0. 	<p>Toxicity is possible if pH is lower than 5.6 or the nutrient solution contains a high micronutrient level (at least 3 ppm iron). If toxicity symptoms are appearing confirm the cause with a soil and tissue analysis. Follow the fertilizer and lime drench instructions described at left, and reapply lime drench if pH has not climbed to 5.6.</p>	<p>Toxicity is not likely unless there is high micronutrient concentration (at least 5 ppm iron) in the nutrient solution. If iron/manganese toxicity is confirmed with lab analysis, follow the fertilizer and lime drench instructions described at left, and reapply lime drench if pH has not climbed above 5.6.</p>

Geraniums can be more easily combined with the Petunia Group when plants are mature.

Organize greenhouse zones so that plants within the same nutritional group can be managed with one injector or fertilizer tank.


If you have the ability to run different fertilizers, use a more acidic-reaction fertilizer (i.e., more ammonium) for the Petunia Group and a more basic-reaction (nitrate-based) fertilizer for the Geranium Group. Check the fertilizer label to determine if it is an acidic- or basic-reaction fertilizer.

If you have high alkalinity and can adjust acidification of irrigation water, acidify for the Petunia Group and not for the Geranium Group.

Some growers will incorporate extra lime (for example 50 percent more) or apply flowable lime at 1:100 into growing medium for the Geranium Group before planting to raise pH above 6.0.

If you use one injector for everything, test pH every 1-2 weeks and be prepared to apply flowable lime to the Geranium Group if media pH is below 6.0, or supplement iron for the Petunia Group if pH is above 6.2.

Managing media EC and media pH go hand in hand. Not only will high media EC suppress media pH, but a high EC is an indication that high levels of fertilizer salts are present, increasing the risk of toxicity for the Geranium Group grown at low pH. In contrast, a low EC indicates that low levels of fertilizer salts are present, increasing the risk of deficiency symptoms in the Petunia Group.

Caution: When applying any chemical, including micronutrients, to a plant, test the application on a small number of plants to check for phytotoxicity before applying to the entire crop. Always read and follow label instructions. 

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