e-GRO Nutritional Monitoring



Josh Henry[1] Brian E. Whipker[1] W. Garrett Owen[2]

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Nutritional Monitoring Series

Verbena

(Verbena ×hybrida)

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Verbena requires low to medium levels of fertility between 100 and 200 ppm N. Optimal substrate pH values range from 5.8 to 6.2. Verbena can develop both low and high substrate pH disorders. High pH inhibits iron (Fe) uptake, leading to symptoms of interveinal chlorosis (yellowing) on the upper leaves. Low pH induces toxic accumulation of Fe and manganese (Mn) in the lower leaves, leading to necrotic (brown) spotting and bronzing.

Figure 1. Excessively high soluble salts [referred to as electrical conductivity (EC)] causes necrosis (browning) of the lower leaves of verbena (*Verbena ×hybrida*). Photo by: Josh Henry.

Target Nutrition Parameters

pH Category III:
5.8 to 6.2

Fertility Category:
Low to Medium
100 to 200 ppm N

EC Category A, B:
1:2 Extraction:
0.4 to 0.9 mS/cm

SME:
0.9 to 2.0 mS/cm

PourThru:
1.3 to 3.0 mS/cm

[1]North Carolina State University
bwhipker@ncsu.edu
[2]Michigan State University
wgowen@msu.edu

Figure 2. Low soluble salts [referred to as electrical conductivity (EC)] causes chlorosis (yellowing) and occasional reddening on the lower leaves of verbena (*Verbena ×hybrida*). Photo by: Josh Henry.

Figure 3. Low soluble salts [referred to as electrical conductivity (EC)] chlorosis (yellowing) and occasional reddening on the lower leaves of verbena (*Verbena ×hybrida*). Photo by: Josh Henry.

Fertility Management of Verbena

Verbena can be propagated by seeds and vegetative cuttings. Fertilization of seed grown verbena should begin once cotyledons expand using 14-0-14 at a rate of 50 to 75 ppm N (Nau, 2011). Once the first true leaves expand, increase fertility to 100 to 150 ppm N. At this stage, use a low P fertilizer such as 13-2-13 or alternate between a high and low formulation (e.g. 14-0-14 and 20-10-20).

Fertilization should begin for cuttings once root initials are visible by providing a rate of 50 to 75 ppm N. Once roots develop and mature, increase fertility to 100 to 150 ppm N. Fully rooted cuttings or liners can receive increased fertility of 150 to 200 ppm N applied twice a week (Nau, 2011).

After transplant, use a constant liquid feed program using a complete fertilizer formulation mixed at 150 to 200 ppm N (Nau, 2011). Seed grown verbena can be sensitive to high soluble salts [referred to as electrical conductivity (EC)], so it is important to occasionally apply a clear water irrigation to avoid excess salts accumulation or reduce the fertility rate and monitor substrate EC. If EC continues to increase over time, this is an indication that the fertility concentration applied is greater than the plant's demand, so decrease the fertilizer rate by 25% to avoid wasting fertilizer. Verbena propagated from vegetative cuttings may be more vigorous, therefore may require higher levels of fertility (Nau, 2011).

High substrate EC can cause chlorotic (yellow) and necrotic (brown) spotting on the lower foliage (Fig. 1). In contrast, low substrate EC also causes chlorosis on the lower

leaves but in a more uniform pattern. Low EC may also cause a red coloration to develop on the lower foliage, but this may be cultivar dependent (Figs. 2 & 3). A visual comparison of plants grown with low and high EC can be seen in Fig. 4.

Substrate pH should be maintained between 5.8 and 6.2. Values below this range cause iron (Fe) and/or manganese (Mn) to become highly available for uptake and induce Fe and/or Mn toxicity (Schoellhorn, 2012). Symptoms of low pH-induced Fe and/or Mn toxicity appear as necrotic spotting and bronzing of the lower leaves (Fig. 5). Symptoms may also appear as blackening of the lower leaf margins (Fig. 6). High substrate pH limits Fe uptake and can induce Fe deficiency, leading to a light chlorotic appearance on the upper foliage (Figs. 7 & 8). A comparison of plants grown with low and high pH can be seen in Fig. 9.

Table 1 lists recommended nutrient ranges for verbena (Bryson and Mills, 2015), which can help in diagnosing suspected nutrient disorders. Conduct routine foliar analyses to ensure nutrients are within the recommended ranges.

Summary

Maintaining low to medium fertility at 100 to 200 ppm N and a pH of 5.8 to 6.2 can help you to produce healthy verbena without pH or EC related nutrient disorders.

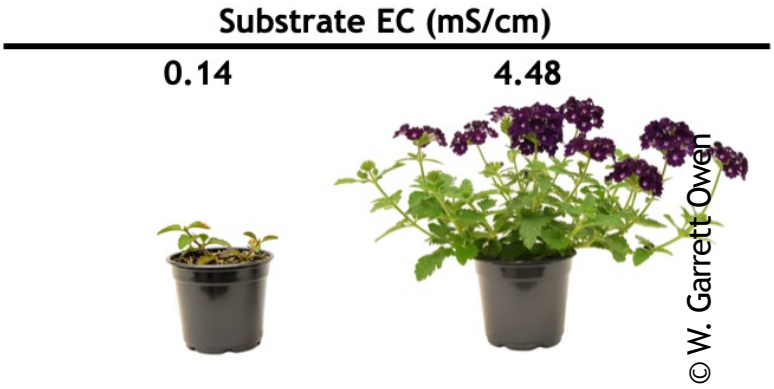

Figure 4. Low soluble salts [referred to as electrical conductivity (EC)] chlorosis (yellowing) and severe stunting (left) in verbena (*Verbena ×hybrida*) compared to plants grown with adequate or high EC (right). Photo by: W. Garrett Owen.

Figure 5. Low substrate pH causes toxic iron (Fe) and manganese (Mn) accumulation and symptoms of necrotic (brown) spotting and bronzing on the lower leaves of verbena (*Verbena ×hybrida*). Photo by: Josh Henry.

Figure 6. Low substrate pH causes toxic iron (Fe) and manganese (Mn) accumulation and symptoms of marginal blackening on the lower leaves of verbena (*Verbena ×hybrida*). Photo by: W. Garrett Owen.

Literature Cited

Bryson, G.M. and H.A. Mills. 2015. Plant analysis handbook IV. Micro Macro Publishing, Athens, GA.

Nau, J. 2011. Ball Redbook volume 2: Crop production. 18th ed. Ball Pub., West Chicago, IL.

Schoellhorn, R. 2012. Crop culture report: Verbena Superbena series. GPN Magazine.

Figure 7. High substrate pH limits iron (Fe) availability, leading to symptoms of interveinal chlorosis (yellowing) on the upper leaves of verbena (*Verbena ×hybrida*). Photo by: Josh Henry.

Figure 8. High substrate pH limits iron (Fe) availability, leading to symptoms of interveinal chlorosis (yellowing) on the upper leaves of verbena (*Verbena ×hybrida*). Photo by: Josh Henry.

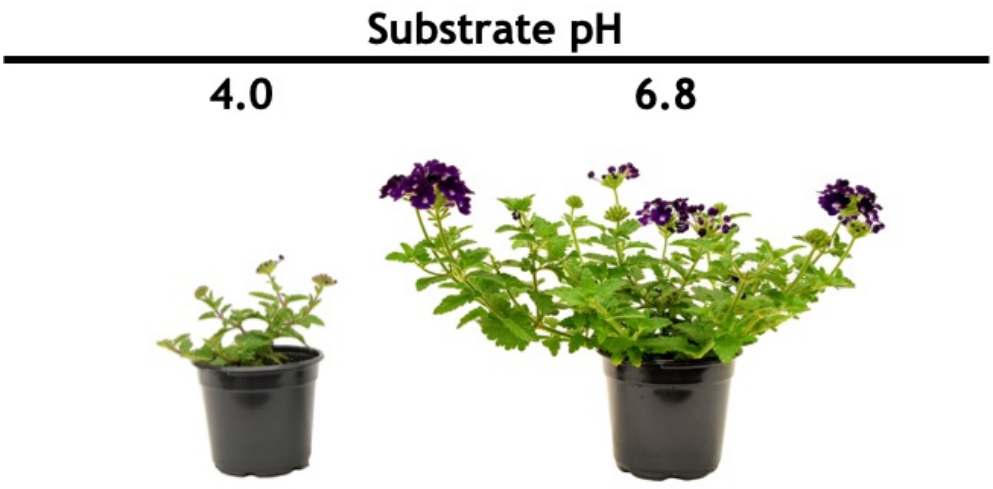

Figure 9. Low substrate pH causes stunting and symptoms of bronzing or marginal blackening on the lower leaves (left) of verbena (*Verbena ×hybrida*) compared to plants grown with high pH (right). Photo by: W. Garrett Owen.

Table 1. Recommended range of leaf tissue analysis for verbena (*Verbena ×hybrida*).

Element		Recommended Range [1]
Nitrogen (N)	(%)	3.64 – 5.84
Phosphorus (P)		0.77 – 1.19
Potassium (K)		2.79 – 4.69
Calcium (Ca)		1.60 – 2.54
Magnesium (Mg)		0.73 – 1.58
Sulfur (S)		0.58 – 0.64
Iron (Fe)	(ppm)	56 – 112
Manganese (Mn)		55 – 293
Zinc (Zn)		65 – 127
Copper (Cu)		3 – 13
Boron (B)		43 – 48

[1] Source: Bryson and Mills (2015).

Corrective Procedures for Modifying Substrate pH and Electrical Conductivity (EC)

When the pH or substrate electrical conductivity (EC) drifts into unwanted territory, adjustments must be made. Below are the standard corrective procedures used to modify the substrate pH and EC for greenhouse grown crops in soilless substrates.

1. Low Substrate pH Correction

When Fe and Mn toxicity becomes a problem, adjust (raising) substrate pH to the recommended pH range. Corrective procedures to raise low pH levels are listed below. Switching to a basic fertilizer when the substrate pH is nearing the lower limit will help stabilize the pH. If the pH is below the recommended range, then corrective procedures will need to be implemented. Flowable lime is one option. Using a rate of 2 quarts per 100 gallons of water will typically increase the substrate pH by roughly 0.5 pH units. Two quarts can be used through an injector. Additional applications can be made if needed. Potassium bicarbonate ($KHCO_3$) can also be applied. A rate of 2 pounds per 100 gallons of water will increase the substrate pH by roughly 0.8 pH units. This treatment will also provide excessive potassium (K) and cause a spike in the substrate EC. A leaching irrigation with clear water is required the following day to restore the nutrient balance (the ratio of K:Ca:Mg) and lower the EC. As always, remember to recheck your substrate pH to determine if reapplications are needed.

pH Adjustment Recommendations

Flowable Lime

- Use 1 to 2 quarts per 100 gallons of water.
  Rinse foliage.
- Avoid damage to your injector by using rates of 2 quarts per 100 gallons of water, or less.
- Can split applications.

Hydrated Lime

- Mix 1 pound in 3 to 5 gallons of WARM water. Mix twice. Let settle. Decant liquid and apply through injector at 1:15.
- Caustic (rinse foliage ASAP and avoid skin contact)

Potassium Bicarbonate ($KHCO_3$)

- Use 2 pounds per 100 gallons of water
- Rinse foliage immediately.
- *Provides 933 ppm K.*
- Leach heavily the following day with a complete fertilizer to reduce substrate EC and restore nutrient balance.
- Rates greater than 2 pounds per 100 gallons of water can cause phytotoxicity!

2. High Substrate pH Correction

The target pH for many species is between 5.8 and 6.2. Higher pH values will result in Fe deficiency and lead to the development of interveinal chlorosis on the upper leaves. Check the substrate pH to determine if it is too high. Be careful when lowering the substrate pH, because going too low can be much more problematic and difficult to deal with.

Acid-based Fertilizer
If the substrate pH is just beginning to increase, then first consider switching to an acidic-based fertilizer. These ammoniacal-nitrogen (N) based fertilizers are naturally acidic and plant nitrogen uptake will help moderate the substrate pH over a week or two.

Acid Water Drench
Some growers use this intermediate correction if pH levels are not excessively high and a quick lower of the substrate pH is desired. Use sulfuric acid to acidify your irrigation water to a pH 4.0 to 4.5. Apply this acid water as a substrate drench providing 5 to 10% excessive leaching of the substrate. Rinse the foliage to avoid phytotoxicity. Results should be visible within 5 days. Retest the substrate pH and repeat if needed.

Iron Drench
If the levels are excessively high, then an Fe chelate application can be made to the substrate.
Below are the options.

Iron Chelate Drench (options)
- Iron-EDDHA: mix 5 ounces in 100 gallons of water
- Iron-DTPA: mix 5 ounces in 100 gallons of water
- Iron sulfate: mix 4-8 ounces in 100 gallons of water

- Apply as a substrate drench with sufficient volume to leach the pot.
- Rinse foliage immediately.
- Avoid use on iron efficient plants (geraniums).

3. Low EC Correction

If low EC problems occur, increase the fertilization rate to 300 ppm N for a few applications before returning to the recommend fertilization rate for the crop.

4. High EC Correction

Excessively high fertilization rates will result in a marginal leaf burn. Check the substrate EC to confirm your diagnosis. Values greater than 6.0 mS/cm based on the PourThru sampling method can be problematic for many plants.

Switch to Clear Water Irrigations
If the substrate EC is just beginning to increase over time, then leach with a few clear water irrigations to lower EC levels by flushing out the salts.

Clear Water Leaching
If the EC values are excessively high, leach the substrate twice with back-to-back clear water irrigations. Then allow the substrate to dry down normally before retesting the EC. If EC levels are still too high, repeat the double leach. Once the substrate EC is back within the normal range, use a balanced fertilizer at a rate of 150 to 200 ppm N.

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CONTRIBUTORS

Dr. Nora Catlin
Floriculture Specialist
Cornell Cooperative Extension
Suffolk County
nora.catlin@cornell.edu

Dr. Chris Currey
Assistant Professor of Floriculture
Iowa State University
ccurrey@iastate.edu

Dr. Ryan Dickson
Greenhouse Horticulture and
Controlled-Environment Agriculture
University of Arkansas
ryand@uark.edu

Nick Flax
Commercial Horticulture Educator
Penn State Extension
nzf123@psu.edu

Thomas Ford
Commercial Horticulture Educator
Penn State Extension
tgf2@psu.edu

Dan Gilrein
Entomology Specialist
Cornell Cooperative Extension
Suffolk County
dog1@cornell.edu

Dr. Joyce Latimer
Floriculture Extension & Research
Virginia Tech
jlatime@vt.edu

Heidi Lindberg
Floriculture Extension Educator
Michigan State University
wolleage@anr.msu.edu

Dr. Roberto Lopez
Floriculture Extension & Research
Michigan State University
rglopez@msu.edu

Dr. Neil Mattson
Greenhouse Research & Extension
Cornell University
neil.mattson@cornell.edu

Dr. W. Garrett Owen
Floriculture Outreach Specialist
Michigan State University
wgowen@msu.edu

Dr. Rosa E. Raudales
Greenhouse Extension Specialist
University of Connecticut
rosa.raudales@uconn.edu

Dr. Beth Scheckelhoff
Extension Educator - Greenhouse Systems
The Ohio State University
scheckelhoff.11@osu.edu

Dr. Paul Thomas
Floriculture Extension & Research
University of Georgia
pathomas@uga.edu

Dr. Ariana Torres-Bravo
Horticulture/ Ag. Economics
Purdue University
torres2@purdue.edu

Dr. Brian Whipker
Floriculture Extension & Research
NC State University
bwhipker@ncsu.edu

Dr. Jean Williams-Woodward
Ornamental Extension Plant Pathologist
University of Georgia
jwoodwar@uga.edu

Cooperating Universities

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Iowa State University
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