e-GRO Nutritional Monitoring

W. Garrett Owen[1]

Brian E. Whipker[2]

Volume 5 Number 7 May 2022

Nutritional Monitoring Series

Angelonia

(*Angelonia augustifolia*)

American Floral Endowment
Funding Generations of Progress Through Research and Scholarships
eGRO Electronic Grower Resources Online
Project Sponsor

Angelonia requires low to moderate fertility of 100 to 200 ppm N. Insufficient fertility results in stunted plants with lower chlorotic (yellow) foliage. Overfertilization results in excessive plant growth. Optimal substrate pH values for angelonia range from 5.8 to 6.2. Substrate pH above 6.2 limits iron uptake and stunts plant growth.

Figure 1. Substrate pH below 5.8 during angelonia (*Angelonia augustifolia*) production may result in lower leaf bronzing or purplish red foliage. Photo by: W. Garrett Owen.

Angelonia

Target Nutrition Parameters

pH Category III:
5.8 to 6.2

Fertility Category:
Low to Medium
100 - 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 2.0 mS/cm

[1]University of Kentucky
wgowen@uky.edu
[2]NC State University
bwhipker@ncsu.edu

Figure 2. Substrate pH above 6.5 can typically inhibit plant growth or induce interveinal chlorosis (yellowing) with angelonia (*Angelonia augustifolia*). Photo by: Brian Whipker.

Figure 3. Providing insufficient fertility [low electrical conductivity (EC)] during angelonia (*Angelonia augustifolia*) production can result in stunted plant growth and lower chlorotic (yellow) foliage. Photo by: W. Garrett Owen.

Fertility Management of Angelonia

Angelonia should be grown with a substrate pH range of 5.8 to 6.2. Use recommended 1:2 Extraction, SME, or PourThru methods to determine and monitor substrate pH and soluble salts [referred to as electrical conductivity (EC)] values. Additionally, conduct routine foliar analysis tests to monitor crop nutrient status. Leaf tissue nutrient levels found in leaves of young plants and vegetative mature plants are listed in Table 1, which can serve as a guideline in diagnosing suspected nutrient disorders. Monitoring substrate pH and nutrient status will enable growers to avoid pH induced nutritional disorders.

Substrate pH below 5.8 can result in an increase uptake of iron (Fe) and manganese (Mn) to toxic levels which will accumulate in leaf tissue. For angelonia, low substrate pH symptomology observed during University of Kentucky research trials included lower leaf bronzing or purplish red foliage (Fig. 1). Corrective procedures for low substrate pH should begin around 5.6. Substrate pH below 5.4 to 5.6 will inhibit magnesium (Mg) uptake causing lower or older leaves to become Mg-deficient and exhibit interveinal chlorosis (yellowing). Monthly applications of supplemental Mg in the form of magnesium sulfate ($MgSO_4$; Epsom salts) at a rate of 8 oz./100 gal. of water in areas with naturally occurring Mg in the water supply or 16 oz./100 gal. of water in areas lacking Mg in the irrigation water will prevent Mg deficiency and symptomology development.

High substrate pH above 6.5 can inhibit Fe uptake causing newly developed and recently matured leaves to become Fe-deficient (Fig. 2). Should substrate pH begin to rise above 6.2, then a corrective action is needed to ensure nutrient availability and uptake for optimal plant growth.

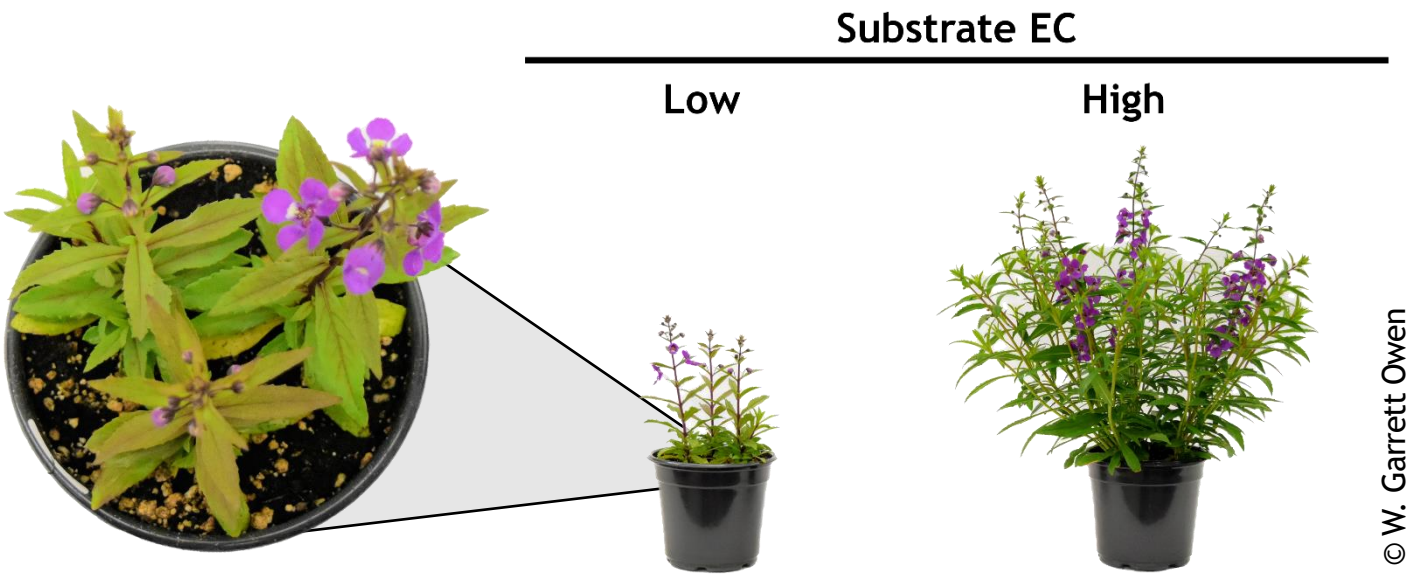

Figure 4. Providing insufficient fertility [low electrical conductivity (EC)] during angelonia (*Angelonia augustifolia*) production results in poorly branched plants (left), while excessive fertility [high EC] can result in excessive plant growth (right). Image by: W. Garrett Owen.

Angelonia can be propagated from seed or vegetative cuttings. For seed propagated angelonia, fertilization can begin during Stage 2 [radical, hypocotyl (stem), and cotyledons (seedling leaves) emergence] of plug production. Begin providing ≤ 100 ppm nitrogen (N) from a nitrate-based fertilizer (Nau, 2021). At Stage 3 (true leaves develop), increase fertility and provide 100 to 175 ppm N. Maintain the fertility regime during Stage 4 (toning or hardening off for transplant). Once plugs are transplanted into their final containers, begin providing a moderate fertilization rate of 175 to 200 ppm N. Growers should use fertilizers that are predominately nitrate-nitrogen based with low phosphorus and high potassium (Nau, 2021). Furthermore, fertilizers with calcium will aid in strengthening nodes, which will prevent stem node brittleness (Nau, 2021).

During vegetative cutting propagation, a fertility program can start during callusing, but only if the foliage color of the cuttings begins to fade. If this occurs, apply 50 to 75 ppm N from a 15-0-15 fertilizer as a foliar feed (Nau, 2021). However, if the aforementioned phenomenon does not occur, then the fertility program can begin when angelonia cuttings develop visible root initials. Provide 100 ppm N from 15-0-15 fertilizer and alternate with 20-10-20 (Nau, 2021). As adventitious roots develop, increase fertility to 150 ppm N. To tone cuttings, provide 150 to 200 ppm N from either a 15-0-15 or 20-10-20 fertilizer. Once liners are transplanted into their final containers, begin providing a moderate fertilization rate of 150 to 200 ppm N. In general, fertilize with 20-10-20 and alternate with 15-0-15. Do not allow fertilizer soluble salts to accumulate in the substrate. A clear water irrigation at every third watering is recommended (Nau, 2021) unless EC values are below 0.4, 0.9, or 1.3 mS/cm as determined with the 1:2 Extraction, SME, or PourThru methods, respectively. An alternative to a clear water irrigation is to reduce the overall N fertilization rate so that the measured EC levels are

Table 1. Foliar nutrient concentration ranges of young plants and vegetative mature plants of angelonia (*Angelonia augustifolia*).

Element		Recommended Range [1]	
		Young Plants	Vegetative Mature
Nitrogen (N)	(%)	3.43 – 4.66	4.63 – 5.06
Phosphorus (P)		0.34 – 0.50	0.44 – 0.63
Potassium (K)		2.36 – 3.34	2.82 – 3.47
Calcium (Ca)		0.30 – 0.80	0.88 – 1.18
Magnesium (Mg)		0.19 – 0.39	0.24 – 0.30
Sulfur (S)		0.13 – 0.51	0.33 – 0.51
Iron (Fe)	(ppm)	62.4 – 125.3	99.6 – 110.0
Manganese (Mn)		47.7 – 184.4	83.6 – 108.7
Zinc (Zn)		43.3 – 106.8	59.4 – 86.2
Copper (Cu)		2.2 – 11.2	8.3 – 12.4
Boron (B)		26.5 – 47.4	29.6 – 46.2
Molybdenum (Mo)		1 – 5	1 – 5

Source: [1] Bryson and Mills (2015)

stable and within the recommended range.

During angelonia production, maintain low to moderate fertility levels of 100 to 200 ppm N. Insufficient fertility levels (low EC) will often result in stunted plant growth with chlorotic foliage (Fig. 3). Nau (2021) reported low fertility concentrations will result in poorly branched plants (Fig. 4). Overfertilization (high EC) results in excessive plant growth (Fig. 4). If EC values become excessive, leach the substrate with clear irrigation water twice before providing fertility. It is best to monitor the crop to avoid excessive EC values than to waste fertilizer by leaching it from the pots. Furthermore, high ammonia concentrations in the substrate can cause excessive vegetative growth (Nau, 2021). Sampling substrate for nutrient concentrations may be necessary to determine if excessive growth is contributed to ammonium-based fertilizers.

Summary

Providing low to medium fertility at 100 to 200 ppm N and maintaining a pH of 5.8 to 6.2 will help prevent most nutritional disorders.

Literature Cited

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

Nau, J. 2021. Ball redbook,19th ed. Ball Publishing, W. Chicago, IL.

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.

American Floral Endowment
Funding Generations of Progress Through Research and Scholarships
eGRO Electronic Grower Resources Online
Project Sponsor

e-GRO Alert

www.e-gro.org

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

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

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

Dr. Chieri Kubota
Controlled Environments Agriculture
The Ohio State University
kubota.10@osu.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
Greenhouse Extension & Research
University of Kentucky
wgowen@uky.edu

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

Dr. Alicia Rihn
Agricultural & Resource Economics
University of Tennessee-Knoxville
arihn@utk.edu

Dr. Debalina Saha
Horticulture Weed Science
Michigan State University
sahadeb2@msu.edu

Dr. Beth Scheckelhoff
Extension Educator - GreenhouseSystems
The Ohio State University
scheckelhoff.11@osu.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

Copyright ©2022

Where trade names, proprietary products, or specific equipment are listed, no discrimination is intended and no endorsement, guarantee or warranty is implied by the authors, universities or associations.

Cooperating Universities

Cornell CALS College of Agriculture and Life Sciences

Cornell Cooperative Extension Suffolk County

Iowa State University

University of Kentucky

PennState Extension

Virginia Tech

Michigan State University

UConn

College of Agricultural & Environmental Sciences University of Georgia

Purdue University

NC State University

The Ohio State University

Division of Agriculture Research & Extension University of Arkansas System

In cooperation with our local and state greenhouse organizations

Maumee Valley Growers — Choose the Very Best.

Metro Detroit Flower Growers Association

NC Flower Power

Western Michigan Greenhouse Association

Connecticut Greenhouse Growers Association

Indiana Flower Growers Association

LIFGA

Michigan Greenhouse Growers Council

NYSFI New York State Flower Industries, Inc.

Kentucky Horticulture Council