e-GRO Nutritional Monitoring



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Volume 1 Number 10 March 2018

Nutritional Monitoring Series

Calceolaria

(Calceolaria ×herbeohybrida)

Calceolaria can be propagated from seed or vegetative stem-tip cuttings. During production, calceolaria require low fertility of 100 to 150 ppm N. They prefer a pH within the range of 5.5 to 6.2. Substrate pH values above 6.2 can inhibit iron availability and induce interveinal chlorosis or yellowing of the upper foliage.

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Figure 1. A common challenge during calceolaria production is chlorosis (yellowing) and marginal and tip necrosis (death). Photos by: W. Garrett Owen

Calceolaria

Target Nutrition Parameters

pH Category II, III:
5.5 to 6.2

Fertility Category:
Low
100 to 150 ppm N

EC Category A:
1:2 Extraction:
0.4 to 0.6 mS/cm

SME:
0.9 to 1.3 mS/cm

PourThru:
1.3 to 2.0 mS/cm

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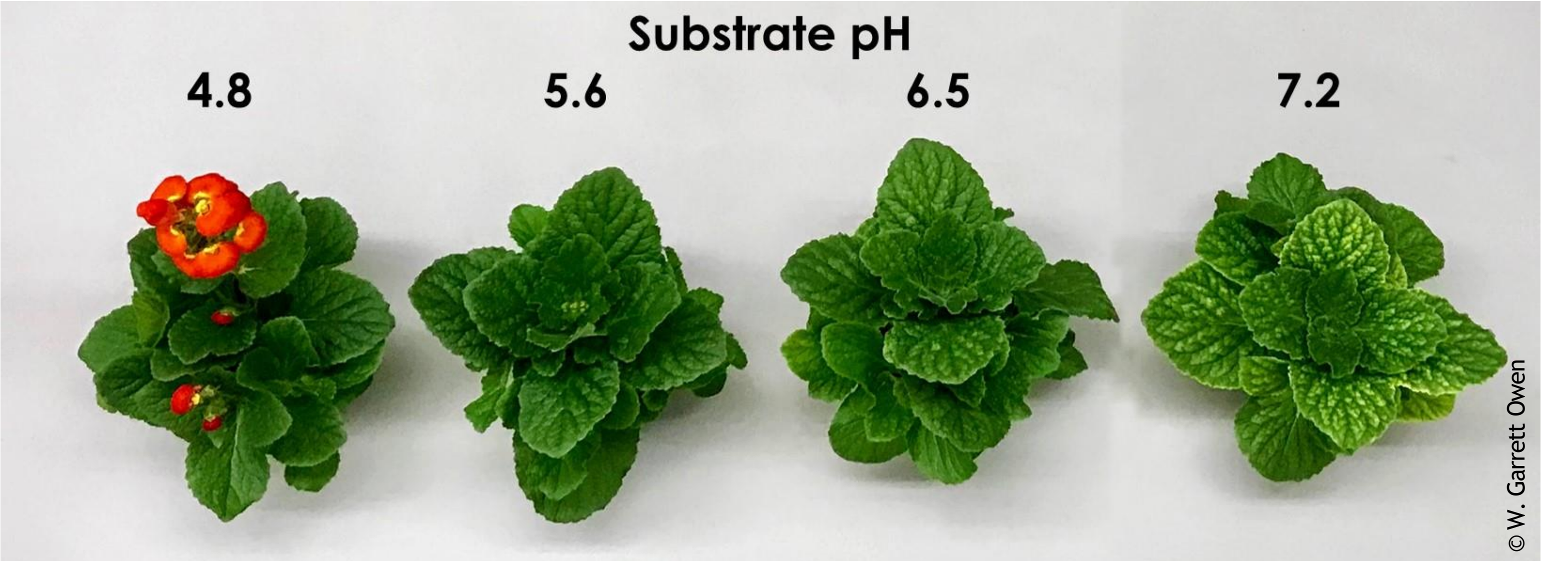

Figure 2. Calceolaria should be grown with a pH range of 5.5 to 6.2. Low or high substrate pH will induce nutrient deficiencies. Substrate pH values presented here were determined using the PourThru procedure. Photo by: W. Garrett Owen

Fertility Management of Calceolaria

A common challenge during calceolaria production is upper leaf chlorosis (yellowing; Fig. 1A) and marginal and tip necrosis (death; Fig. 1B). Upper leaf chlorosis may develop due to low growing temperatures, high or low substrate pH, overfertilization or high soluble salts soluble salts [referred to as electrical conductivity (EC)], poor root system development, poor substrate drainage or aeration, over irrigating, or root rot (Heins et al., 1991).

Calceolaria should be grown with a pH range of 5.5 to 6.2 (Fig. 2). Tissue nutrient levels found in healthy, newly expanded leaves and critical tissue values of calceolaria are listed in Table 1. This range will enable growers to avoid high and low pH nutritional disorders.

Substrate pH above 6.2 will inhibit iron (Fe) uptake, causing newly developed and recently matured leaves to become Fe-deficient and exhibit marginal (Fig. 3) and interveinal chlorosis (Fig. 4). If plants become severely Fe-deficient, interveinal chlorosis intensifies (Fig. 5) and become bleached (white; Fig. 6). Corrective procedures for high substrate pH should begin within the range of 6.2 to 6.4. Maintaining substrate pH below 6.2 will reduce the likelihood of Fe-deficiency from occurring; however, applications of chelated micronutrients, such as Fe and manganese (Mn), may be used to correct these deficiency symptoms (Weiler, 1976; Heins et al., 1991).

Substrate pH below 5.5 will inhibit magnesium (Mg) uptake causing lower or older leaves to become Mg-deficient and exhibit interveinal chlorosis. Corrective procedures for low substrate pH should begin within the range of 5.4 to 5.5. Monthly applications of supplemental Mg in the form of magnesium sulfate ($MgSO4$; Epsom salts) at a rate of 8 oz./100 gallons of water in areas with naturally occurring Mg in the water supply or 16 oz./100 gallons of water in areas lacking Mg in the irrigation water (Whipker, personal communications) may be required if plants exhibit interveinal chlorosis of lower or older leaves. In addition, apply one-half of the labeled rate of a micronutrient supplement once a month to ensure adequate micronutrient levels in the substrate (Erwin, 1994).

Calceolaria are highly sensitive to excessive EC levels and are considered to require low fertility. Calceolaria should be fertilized with 100 to 150 ppm N provided from a well-balanced calcium nitrate [Ca(NO3)2] -based fertilizer. If a controlled-release fertilizer is incorporated into the substrate, one may provide 200 ppm N provided fertilizer at every third watering or 100 ppm N at every other watering (Aimone, 1986).

Substrate EC should remain below 0.6, 1.3, or 2.0 mS/cm, based on the 1:2 Extraction, SME, or PourThru methods, respectively. To avoid high EC, it is recommended to keep the fertilization rate low (100 to 150 ppm N). If levels begin to increase, switch to clear water irrigations to avoid a build up of fertilizer salts in the substrate. If EC levels become excessive, then leach the substrate with clear irrigation water twice before providing fertility. It is best to monitor the crop to avoid excessive EC levels than to waste fertilizer by having to leach it out of the pots.

During winter months when plants are grown under cooler temperatures,

Figure 3. High substrate pH above 6.2 will inhibit iron (Fe) uptake causing newly developed and recently matured leaves to become Fe-deficient and exhibit marginal chlorosis (yellowing). Photos by: W. Garrett Owen

Figure 4. High substrate pH above 6.2 will inhibit iron (Fe) uptake causing newly developed and recently matured leaves to become Fe-deficient and exhibit interveinal chlorosis (yellowing). Photo by: W. Garrett Owen

Figure 5. High substrate pH above 6.5 can inhibit iron (Fe) uptake and if plants become severely Fe-deficient, interveinal chlorosis (yellowing) intensifies and plants become stunted. Photo by: W. Garrett Owen

fertilize with nitrate based fertilizers such as Ca(NO3)2. Avoid fertilizers providing ammonium (NH4-N) such as 20-10-20 or 20-20-20. Calceolarias are sensitive to high levels of ammonium and limiting ammonium sources of fertilizer will limit the possibility of ammonium toxicity due to a lack of nitrifying bacteria activity especially when plants are grown at cool temperatures (Currey, 2017; Hammer, 1997). Ammoniacal-based fertilizers will cause excessive vegetative growth and leaf expansion. Increasing growing temperatures will lower the probability of ammonium toxicity from occurring (White, 1975).

According to Weiler (1976), Table 2 and 3 provide nutrient values that should be maintained in the substrate and nutrient solution, respectively, during calceolaria production.

Therefore, it is important to provide calceolaria with low (100 to 150 ppm N) fertility during crop production and to limit ammoniacal-based fertilizers.

Summary

Providing calceolarias with low fertility ranging 100 to 150 ppm N and maintaining a substrate pH of 5.5 to 6.2 will prevent most nutritional disorders.

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Figure 6. High substrate pH above 6.5 can inhibit iron (Fe) uptake and if plants become severely Fe-deficient, interveinal chlorosis (yellowing) intensifies and plants become bleached (white). Photo by: W. Garrett Owen

Table 1. Leaf tissue nutrient analysis for Calceolaria (Calceolaria ×herbeohybrida ‘Orange’) grown with low (pH 4.8) and high (pH 7.2) substrate pH and reference foliar nutrient concentrations for plants grown within the recommended substrate pH range and a level of 100 ppm N.

Element		Low pH Calceolaria [1]	High pH Calceolaria [1]	Reference Calceolaria [1]
Nitrogen (N)	(%)	4.2	4.6	4.2
Phosphorus (P)		0.4	0.4	0.4
Potassium (K)		2.1	1.7	1.8
Calcium (Ca)		0.8	1.1	0.8
Magnesium (Mg)		0.4	0.6	0.5
Sulfur (S)		0.4	0.6	0.5
Iron (Fe)	(ppm)	68.4	88.8	72.1
Manganese (Mn)		64.2	83.6	73.3
Zinc (Zn)		54.2	62.6	59.4
Copper (Cu)		5.8	11.1	9.3
Boron (B)		37.6	30.5	36.5
Aluminum (Al)		8.5	3.4	8.2
Sodium (Na)		0.06	0.04	0.05
[1]Source: Owen (2018)				

Table 2. Target nutrient values for substrate[1].

Nutrient	Range (ppm)
Nitrogen (N)	80 – 100
Nitrate (NO_3)	22 – 28
Phosphorus (P)	60 – 80
Phosphorous oxide (P_2O_5)	13 – 22
Potassium (K)	150 – 200
Potassium oxide (K_2O)	62 – 83
Magnesium (Mg)	100 – 120
Calcium (Ca)	90 – 100
[1] Weiler (1976)	

Table 3. Target nutrient values for nutrient solution[1].

Nutrient	Range (ppm)
Nitrogen (N)	80 – 100
Nitrate (NO_3)	22 – 28
Phosphorus (P)	20 – 25
Phosphorous oxide (P_2O_5)	4 – 5
Potassium (K)	100 – 130
Potassium oxide (K_2O)	41 - 54
Magnesium (Mg)	20 – 25
Calcium (Ca)	100 – 150
[1] Weiler (1976)	

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, <u>or less.</u>
- Can split applications.

Hydrated Lime

- Mix 1 pound in 3 to 5 gallons of <u>WARM</u> 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.
- <u>*Provides 933 ppm K.*</u>
- <u>Leach heavily</u> the following day with a complete fertilizer to reduce substrate EC and restore nutrient balance.
- Rates <u>greater than</u> 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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