e-GRO Nutritional Monitoring



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Nutritional Monitoring Series

Chrysanthemum, garden

(Chrysanthemum ×morifolium)

Chrysanthemums require medium to high fertility of 150 to 300 ppm N. Optimal substrate pH values for chrysanthemums range from 5.8 to 6.2. Chrysanthemums are susceptible to high substrate pH and soluble salts. Substrate pH above 6.5 inhibits iron availability and induce interveinal chlorosis (yellowing). High soluble salts result in marginal leaf necrosis (death).

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Figure 1. High substrate pH above 6.2 will inhibit iron (Fe) uptake causing newly developed and recently matured leaves of garden chrysanthemum (*Chrysanthemum ×morifolium*) to become Fe-deficient and exhibit marginal chlorosis (yellowing). Photo by: W. Garrett Owen

Target Nutrition Parameters

pH Category III:
5.8 to 6.2

Fertility Category:
Medium to High
150 to 300 ppm N

EC Category B - C
(During Active Growth):
1:2 Extraction:
0.6 to 1.5 mS/cm

SME:
1.3 to 3.3 mS/cm

PourThru:
1.3 to 4.3 mS/cm

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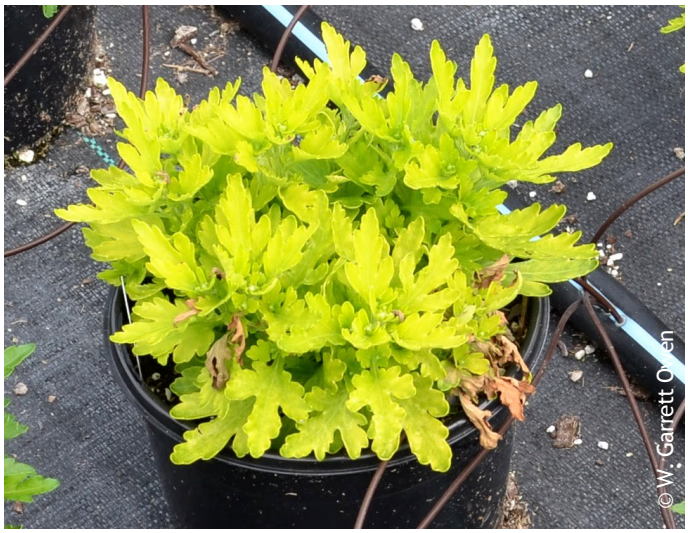

Figure 2. High substrate pH above 6.5 can inhibit iron (Fe) uptake and if garden chrysanthemum (*Chrysanthemum ×morifolium*) become severely Fe-deficient, interveinal chlorosis (yellowing) intensifies and plants become completely chlorotic or bleached (white). Photo by: W. Garrett Owen

Figure 3. Substrate pH below 5.8 will inhibit magnesium (Mg) uptake causing lower or older leaves of garden chrysanthemum (*Chrysanthemum ×morifolium*) to become Mg-deficient and exhibit interveinal chlorosis (yellowing). Photo by: W. Garrett Owen

Fertility Management of Garden Chrysanthemum

Chrysanthemum should be grown with a substrate pH range of 5.8 to 6.2. Substrate pH influences nutrient availability and uptake, therefore use recommended 1:2 Extraction, SME, or PourThru methods to determine and monitor substrate pH and soluble salt [referred to as electrical conductivity (EC)] values. Additionally, conduct routine foliar analysis tests to monitor crop nutrient status. Tissue nutrient levels found in healthy, newly expanded leaves of garden chrysanthemums prior to bud set and after bud set are listed in Table 1. Monitoring substrate pH and nutrient status will enable growers to avoid pH induced nutritional disorders.

High substrate pH above 6.5 can inhibit iron (Fe) uptake causing newly developed leaves to become deficient in Fe and exhibit interveinal chlorosis (yellowing; Fig. 1). If plants become severely Fe-deficient, interveinal chlorosis intensifies and leaves become completely chlorotic or bleached (white; Fig. 2). Corrective procedures for high substrate pH should begin within the range of 6.3 to 6.5.

In general garden chrysanthemums do not exhibit symptoms of accumulated Fe and/or manganese (Mn) due to excessively low substrate pH. Based on grower observations the primary sign that the substrate pH is too low (<5.0) is slow or stunted plant growth. This may be difficult to detect if the entire planting is being grown in a low substrate pH mix. Periodic pH and EC testing is required early in the crop to ensure the levels are within the recommended parameters.

Substrate pH below 5.8 will inhibit magnesium (Mg) uptake causing lower or older leaves to become Mg-deficient and exhibit interveinal chlorosis (Fig. 3). In severe cases, leaves

Figure 4. Substrate pH below 5.8 will inhibit magnesium (Mg) uptake causing lower or older leaves of garden chrysanthemum (*Chrysanthemum ×morifolium*) to become Mg-deficient and in severe cases, leaves will exhibit reddish spots along leaf margins and between the veins. Photo by: W. Garrett Owen

Figure 5. Garden chrysanthemums (*Chrysanthemum ×morifolium*) observed with Ca deficiency will exhibit small, curled, and thickened leaves around the meristem. Photo by: W. Garrett Owen

will exhibit reddish spots along leaf margins and between the veins (Fig. 4) progressing to upper leaves. Corrective procedures for low substrate pH should begin within the range of 5.5 to 5.7. Monthly applications of supplemental Mg in the form of magnesium sulfate ($MgSO_4$; 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. With the prevalence of Mg deficiency symptoms appearing on garden mums, it is likely a species that requires supplemental applications of Mg.

Chrysanthemums are started from unrooted or rooted vegetative cuttings. For unrooted cuttings, little to no fertility is required from stick until root initiation. One may choose to begin a fertility program at cutting stick, but nutrient uptake is limited without roots and often wasteful. However, Nau (2011) indicated fertility can be provided at 1, 5, and 10 days after sticking providing 300 ppm N from a complete fertilizer such as 20-10-20. Once roots are visible, begin a water-soluble fertilizer (WSF) program providing 250 to 300 ppm N from 20-10-20 (Nau, 2011).

Once cuttings are rooted and toned or received from a commercial propagator, they can be transplanted into containers and receive nutrition by either WSF, controlled release fertilizers (CRF), or combination of WSF + CRF. In general, chrysanthemums are considered to require medium to high fertility and can be modified throughout production. Implementing a WSF program enables growers to reduce fertility. For instance, Yates (2015) reported a production schedule with three fertility periods: high (first 2 – 3 weeks of production), regular (until buds first crack color), and reduced (first

color to sale). Nau (2011) indicated a WSF program during weeks 1 to 5 providing 250 to 300 ppm N from 20-10-20 at every irrigation; from weeks 6 to 9, reduce to 150 to 200 ppm N provided by 15-0-15 at every irrigation; and at week 10 to sale, discontinue fertility and provide clear irrigation. Whipker and Cloyd (1998) recommended using 15-5-15 Cal-Mag or 20-10-20 (with supplemental calcium (Ca), Mg, and micronutrients) or a fertilizer providing 60 to 75% of the nitrogen as nitrate-nitrogen (NO_3-N). Chrysanthemums with Ca deficiency will exhibit small, curled, and thickened leaves around the meristem (Fig. 5; Whipker and Cloyd, 1998). Furthermore, Henry and Whipker (2017) observed reproductive stage phosphorus (P) deficiency of 'Swifty Yellow', 'Little Rock', and 'Crystal Misty Purple' pot chrysanthemums. Symptoms occur below the flower buds and was observed as chlorosis, purpling, marginal necrosis, and olive-green spotting (Fig. 6). It is recommended to supply ~5 to 10 ppm P throughout the production cycle to avoid reproductive stage P deficiency.

Controlled release fertilizers can be used for chrysanthemum production and either amended into substrates prior to or topdressed after transplanting rooted cuttings. Controlled release fertilizers are most commonly used for outdoor chrysanthemum production and when overhead irrigation is the primary irrigation method. Yates (2015) reported 12-4-11, 13-11-11, or 15-9-2 are suitable CRFs to topdress chrysanthemums. However, any use of CRF requires the use of WSF in the initial 2 weeks post-

Figure 6. Symptom progression of reproductive stage phosphorus (P) deficiency in 'Little Rock' (Top), 'Swifty Yellow' (Middle), and 'Crystal Misty Purple' (Bottom) pot chrysanthemums (*Chrysanthemum ×morifolium*). Photo by: Josh Henry

Figure 7. High soluble salts [referred to as electrical conductivity (EC)] causes wilting, marginal leaf necrosis (death) of garden chrysanthemum (*Chrysanthemum ×morifolium*). The plant closest to the drip emitter was affected due to high EC. The EC of the substrate was 6.3 mS/cm determined by the PourThru extraction method. Photo by: Brian Whipker

transplant (Yates, 2015). To achieve this, one may consider drip irrigation. A combination of both CRF and WSF delivered by drip irrigation provides growers with flexibility and adjustments can be made to the fertility program.

Regardless of fertility delivery method, garden chrysanthemums are sensitive to high EC. Routinely check substrate EC and maintain below 1.5, 3.3, or 4.3 mS/cm, based on the 1:2 Extraction, SME, or PourThru methods, respectively. When leaching is limited or crops are overfertilized or irrigated with water containing high amounts of dissolved salts, excessive EC injury can occur. Symptoms of high EC include marginal leaf necrosis (death; Fig. 7) and root loss. This is often observed when chrysanthemums are drought (water) stressed, when applying fertilizer to dry substrate (Yates, 2015), or when little leaching has occurred. If EC 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 WSF. It is better to monitor the crop to avoid excessive EC levels than to waste fertilizer by having to leach it out of the substrate.

Low EC symptoms such as stunted plants, lack of growth, lower leaf chlorosis (yellowing; Fig. 8), and poor flowering can be observed when fertility is insufficient. Additionally, outdoor crops can exhibit low EC symptoms after heavy rainfall, growers can provide 200 to 300 ppm N thereby replenishing leached nutrients.

Summary

Providing chrysanthemum with a moderate to high level of fertility ranging from 150 to 300 ppm N and maintaining a substrate pH of 5.8 to 6.2 will prevent most nutritional disorders from occurring.

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Figure 8. Providing insufficient fertility [low electrical conductivity (EC)] during garden chrysanthemum (*Chrysanthemum ×morifolium*) production can result in lower leaf chlorosis (yellowing) or reddening. Photo by: Brian Whipker

Table 1. Leaf tissue nutrient sufficiency range recommended for garden chrysanthemum (*Chrysanthemum ×morifolium*) prior to bud set and after bud set.

Element		Prior to bud set [1]	After bud set [2]
Nitrogen (N)	(%)	4.00 – 6.00	4.00 – 6.30
Phosphorus (P)		0.20 – 1.20	0.25 – 1.00
Potassium (K)		1.00 – 10.00	4.00 – 7.00
Calcium (Ca)		0.50 – 4.60	1.00 – 2.00
Magnesium (Mg)		0.10 – 1.50	0.25 – 1.00
Sulfur (S)		0.25 – 0.70	0.25 – 0.70
Iron (Fe)	(ppm)	20 – 750	50 – 250
Manganese (Mn)		25 – 375	50 – 250
Zinc (Zn)		5 – 250	20 – 250
Copper (Cu)		5 – 50	6 – 30
Boron (B)		20 – 200	25 – 75
[1,2] Bryson and Mills (2014) for garden chrysanthemum grown in greenhouses. These values represent the most recently matured leaves prior to bud set and after bud set.			

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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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