e-GRO Nutritional Monitoring




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Nutritional Monitoring Series

Lettuce

(Lactuca sativa)

American Floral Endowment
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Lettuce requires medium levels of fertilization, growing best with 150 to 200 ppm N or 1.0 to 2.0 mS/cm for hydroponic nutrient solutions. Lettuce transplants grown in soilless substrates have a wider optimal pH range of 5.5 to 6.5. Hydroponic solution pH values should be maintained between 5.5 and 6.0 with an optimal

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Figure 1. Low soluble salts [referred to as electrical conductivity (EC)] can cause lower leaf chlorosis (yellowing) on green lettuce (*Lactuca sativa*) cultivars (top) or a dark purpling on red cultivars (bottom). Photo by: Josh Henry.

Lettuce

Target Nutrition Parameters

pH Category II to IV:
5.5 to 6.5 (substrate)
5.5 to 6.0 (hydroponic)

Fertility Category: Medium
150 to 200 ppm N (substrate)
1.0 to 2.0 mS/cm (hydroponic)

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

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Figure 2. High soluble salts [referred to as electrical conductivity (EC)] can cause excessive vegetative growth, premature bolting, and chlorotic (yellow) and necrotic (dead) spotting on the lower leaves of lettuce (*Lactuca sativa*). Photo by: Josh Henry.

Figure 3. High soluble salts [referred to as electrical conductivity (EC)] can cause chlorotic (yellow) and necrotic (dead) spotting on the lower leaves of lettuce (*Lactuca sativa*). Photo by: Josh Henry.

value of 5.8. Excessively high or low salts can significantly affect the quality of greenhouse-grown lettuce. Additionally, tipburn caused by calcium deficiency is a common issue.

Fertility Management of Lettuce

Symptoms of nutritional disorders can vary among green and red-leafed lettuce types. Low soluble salts [referred to as electrical conductivity (EC)] can cause chlorosis (yellowing) or purpling on the lower foliage (Fig. 1). High EC can cause excessive vegetative growth and can cause premature bolting (Fig. 2). Additionally, high salts cause necrotic (dead) spotting on the lower foliage (Fig. 3). Low pH can cause stunting, chlorosis, and necrotic spotting on the lower foliage (Fig. 4). High pH can limit iron (Fe) availability, leading to interveinal chlorosis on the upper leaves (Fig. 5).

Lettuce transplants grown in peat-based or other soilless substrates requires medium levels of fertility ranging from 150 to 200 ppm N. Liu et al. (2012) recommend subirrigating transplants with 200 ppm N. To correct high EC, apply clear water to leach excess salts. The substrate pH should be maintained between 5.5 and 6.5. Substrate pH values >6.5 inhibit Fe uptake.

Hydroponic lettuce should be grown with a narrower pH range of 5.5 to 6.0, with an optimal target value of 5.8. During germination, hydroponic lettuce should be fertilized with 100 to 150 ppm N, maintaining a solution EC around 1.2 mS/cm. During production, maintain a solution EC of 1.5 mS/cm.

Calcium (Ca) deficiency induced tipburn is a common symptom observed in greenhouse lettuce production (Fig. 6). Symptoms appear as a marginal necrosis and puckering that occurs primarily around the tips of young immature leaves. Calcium nitrate ($CaNO_3^-$) sources of fertilizer can help alleviate this problem. It is important to note that $CaNO_3^-$ must be maintained in a separate stock tank than other fertilizers so as to prevent Ca from precipitating out of solution. Tipburn can be observed even with sufficient Ca levels in substrate or hydroponic solutions due to limited Ca mobility. Increasing transpiration by providing adequate air movement will help facilitate Ca movement to the upper leaves.

Periodically take tissue samples from the most recently matured leaves and submit for tissue analysis to help verify suspected nutritional problems. The nutrient values may then be compared with published sufficiency values (Table 1).

Summary

Calcium availability and conditions promoting uptake are important factors for lettuce production. Maintaining moderate fertility at 150 to 200 ppm N (substrate) or 1.0 to 2.0 mS/cm (hydroponic) and a pH of 5.5 to 6.0 or 5.5 to 6.5 for lettuce grown in hydroponic or soilless substrates, respectively, should produce healthy lettuce without developing nutritional disorders.

Figure 4. Low substrate pH causes a dull purple coloration in red lettuce cultivars with chlorosis (yellowing) on the lower leaves of lettuce (*Lactuca sativa*). Photo by: Josh Henry.

Figure 5. High substrate pH leads to interveinal chlorosis (yellowing) on the upper leaves of lettuce (*Lactuca sativa*). Photo by: Brian Whipker.

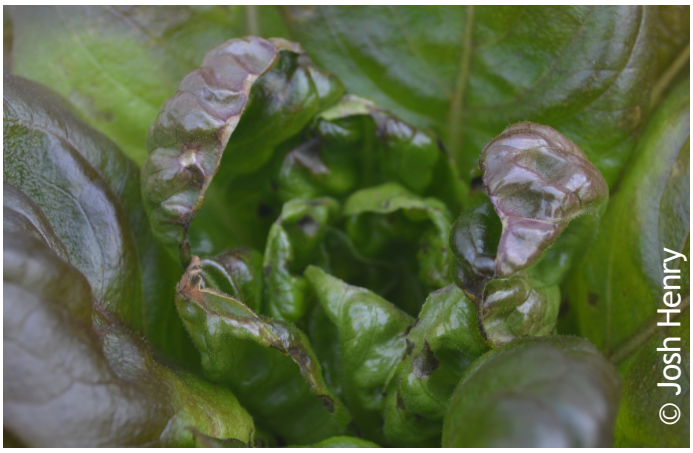

Figure 6. Calcium (Ca) deficiency can lead to tipburn, which includes symptoms of necrotic (dead) margins and puckering around the tips of younger leaves of lettuce (*Lactuca sativa*). Photo by: Josh Henry.

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Table 1. Recommended range of leaf tissue analysis for lettuce (*Lactuca sativa*).

Element		Sufficiency Range	
		Substrate [1]	Hydroponic [2]
Nitrogen (N)	(%)	4.20 - 5.60	3.75 – 5.60
Phosphorus (P)		0.62 – 0.77	0.45 – 0.77
Potassium (K)		7.82 – 13.68	3.00 – 6.50
Calcium (Ca)		0.80 – 1.20	1.25 – 2.50
Magnesium (Mg)		0.24 – 0.73	0.45 – 0.78
Sulfur (S)		0.26 – 0.32	0.25 – 0.35
Iron (Fe)	(ppm)	168 – 223	50 – 150
Manganese (Mn)		55 – 110	55 – 110
Zinc (Zn)		33 – 196	25 – 60
Copper (Cu)		6 – 16	6 – 16
Boron (B)		32 – 43	15 – 45
Molybdenum (Mo)		0.29 – 0.58	0.33 – 0.58

[1] Source: Bryson and Mills (2014) for greenhouse grown Boston or Butterhead lettuce. These values represent the most recently matured leaves.
[2] Source: Bryson and Mills (2014) for hydroponic leaf lettuce. These values represent the most recently matured leaves.

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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