

Symptoms of Common Nutrient Deficiencies in Hydroponic Lettuce

by Neil Mattson and Tanya Merrill

Managing the nutrient solution of hydroponic crops can be much more challenging than container grown crops because: 1) hydroponic solutions are often captured and reused which can, overtime, lead to deficiencies of some elements and excess of others; and 2) pH changes much more quickly in hydroponics than in container-grown plants. Hydroponic growers should monitor nutrient solution pH and EC daily as well as periodically have their nutrient solution tested by a laboratory to make sure nutrient supply meets plant needs. Monitoring plants to look for visual symptoms is another tool that can be used to detect nutrient deficiencies. Lettuce is one of the most commonly grown hydroponic vegetables. Currently there are few resources in the literature regarding photographs and descriptions of common nutrient disorders in hydroponic lettuce. Therefore, the objective of this study was to grow butterhead lettuce in nutrient solutions deficient of individual macro- and micro-nutrients to document visual symptoms of nutrient deficiencies.

Materials and Methods

Pelleted 'Flandria' lettuce seeds were sown in 1-inch (200-cell) rockwool cubes that were previously soaked in reverse osmosis water for 5 minutes and then drained and soaked and drained in a Sonneveld's nutrient solution for lettuce ([Mattson and Peters, 2014](#)). Seedlings were placed in a greenhouse at 68-72 °F with ambient light and hand watered daily (or as needed) with the Sonneveld's nutrient solution. 14-20 days after seeding the lettuce seedlings in rockwool were placed in the lid of 1 gallon buckets filled with the Sonneveld's solution and with an airline from an aquarium pump with an airstone on each end. There was 1 plant per bucket. After the plants had been established in hydroponics for 1 week the nutrient solutions for each bucket were replaced with either a control solution prepared in reverse osmosis water (Table 1) or the control solution minus 1 nutrient element of interest (-N, -P, -K, etc.). Every other day reverse osmosis water was used to raise the solution level in each container back to 1 gallon. Every week the nutrient solution in each container was completely replaced with new solution. Plants were monitored every week and visible symptoms of nutrient deficiency (with reference to the control plants) were noted. There was 1 plant for each nutrient deficiency condition, the experiment was repeated over time for a total of 3 replications.



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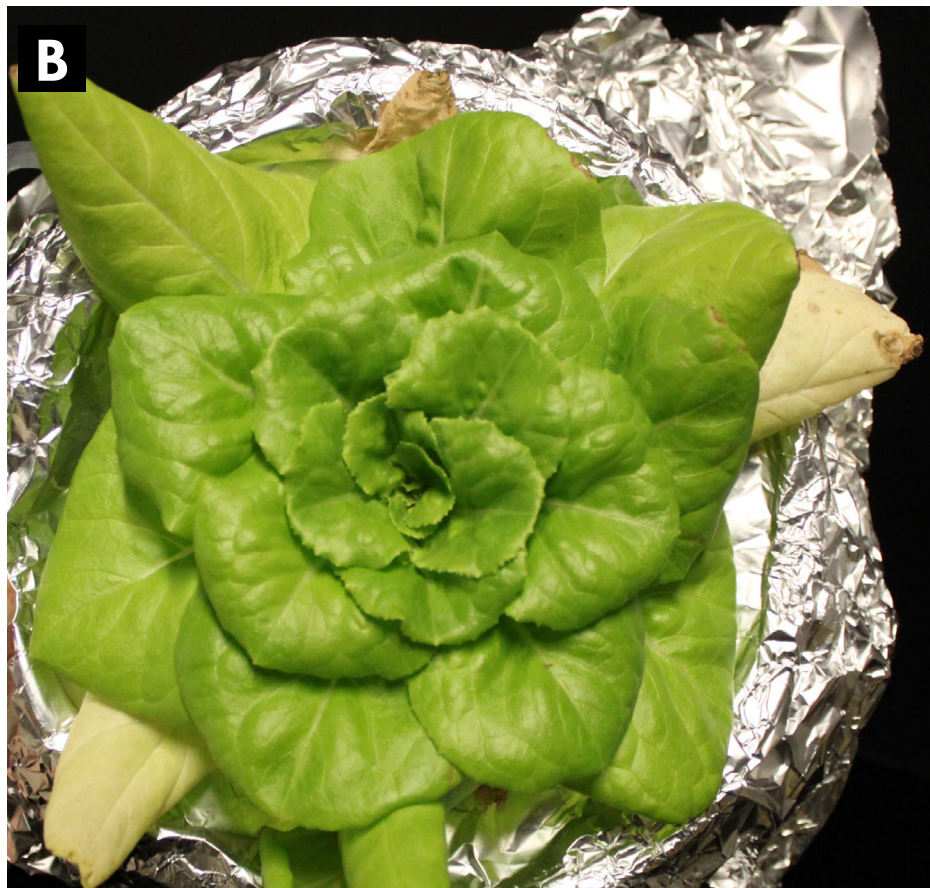
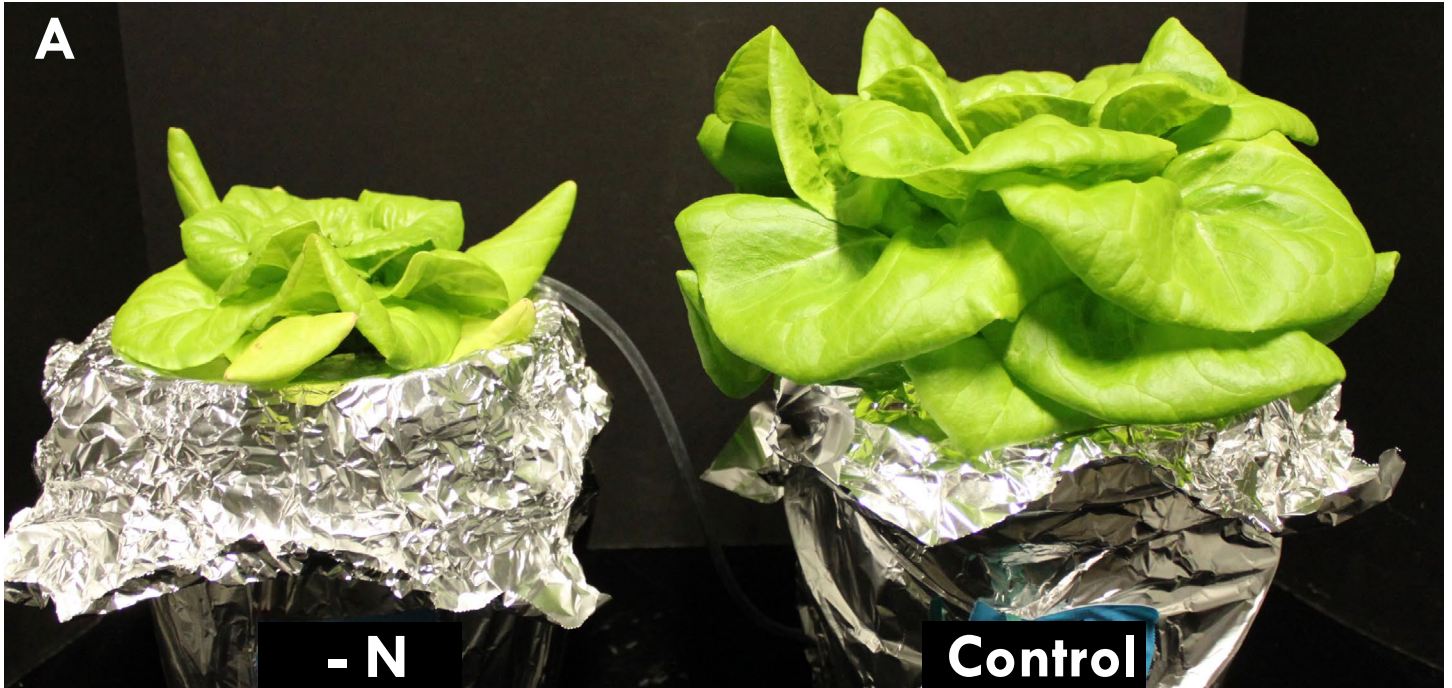
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Summary of Findings

- Our experimental design led to noticeable deficiency symptoms of N, P, K, and Mg on mature leaves.
- Deficiency of Ca, Fe, and B affected new growth and for Fe was eventually also apparent on recently mature leaves.
- S deficiency led to uniform chlorosis along leaves, first evident on new growth and eventually affecting the entire plant.

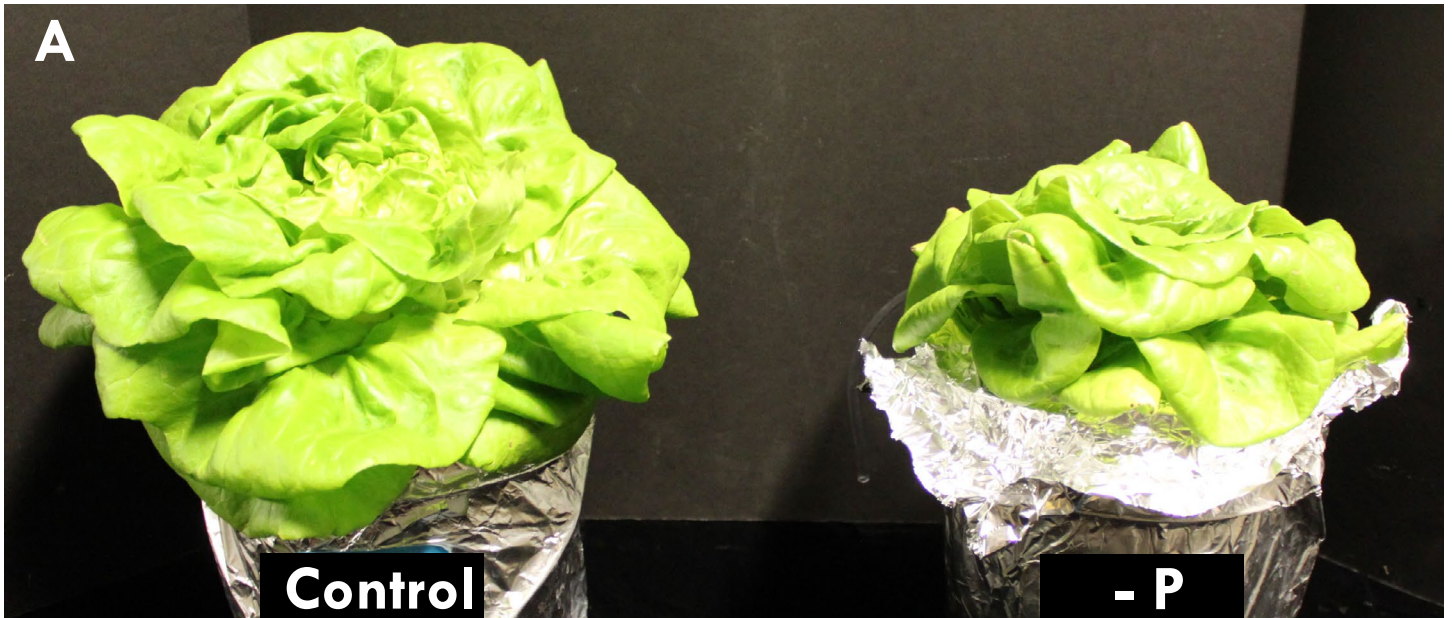
Nitrogen (N)

Nitrogen deficiency initially resulted in lighter green color which proceeded to uniform chlorosis (yellowing) of older leaves. Reduced growth was noticeable within the first two weeks of exposure to the deficient conditions (A). Severe chlorosis of older leaves was observed after three weeks of deficient conditions (B).



Phosphorus (P)

Phosphorous deficient plants were shorter and exhibited much reduced growth compared with control plants, evident within two weeks of deficiency (A). Leaf margins of older leaves exhibited chlorotic regions (B) followed by necrotic spots present after 4 weeks of deficiency (C).



Potassium (K)

Potassium deficiency initially resulted in small necrotic spots on margins of old leaves which advanced to larger necrotic regions as the deficiency continued (A). By the 4th week of deficient conditions, large scattered necrotic regions had developed on mature leaves and leaves began to curl downward (B)



Calcium (Ca)

Within the first week of exposure to the calcium deficient solution there were numerous scattered necrotic spots on young leaves (A) and marginal necrosis and distortion of the youngest leaves (B). The growing tip was completely dead by the third week. Symptoms were much more dramatic than leaf tipburn which typically occurs when there is enough calcium in the nutrient solution but environmental conditions (high humidity, rapid growth) do not allow enough calcium to reach the growing point and new leaves (C). For more on this topic see the [e-Gro Alert Vol. 4, No. 31, April, 2015](#).



Magnesium (Mg)

About 10 days after deficient conditions mature leaves exhibited light interveinal chlorosis (A) and shortly thereafter marginal necrosis was visible (B). After three weeks of Mg deficient conditions, all lower leaves exhibited severe interveinal chlorosis as well as marginal necrosis and some scattered necrotic spots along the leaf blade (C).



Sulfur (S)

Within 10 days of sulfur deficiency, plants exhibited uniform chlorosis across the entire leaf blade. While the whole plant was affected, chlorosis was most pronounced on recently mature leaves and newer growth (A). After 4 weeks of deficient conditions the entire plant was uniformly chlorotic and plant size was much reduced to control plants (B).



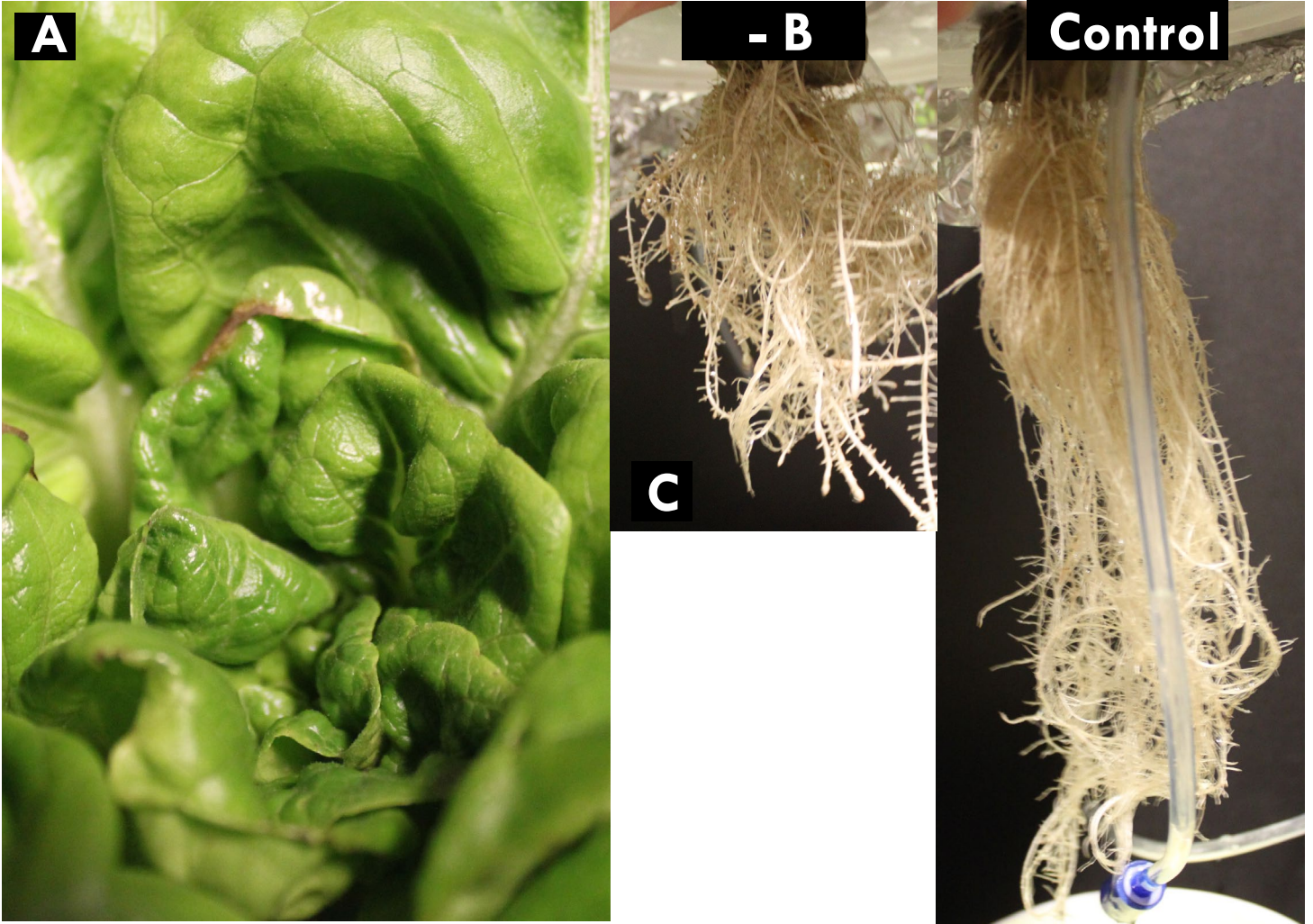
Iron (Fe)

Iron deficiency resulted in interveinal chlorosis of new growth within 10 days of exposure to deficient conditions (A). By the third week similar symptoms became more advanced on the plant and were presented on recently mature and younger leaves (B).



Boron (B)

Early symptoms of B deficiency included distorted new growth with slight marginal necrosis and leaves cupping upward (A), as symptoms advanced the growing point became crowded with new leaves that were not properly unfolding/expanding (B). The root system was much smaller than control plants with short primary roots (C).



Discussion

The timeline for development of symptoms may vary based on your environmental conditions. Many nutrient disorders are similar in appearance, therefore laboratory analysis of leaves is necessary to verify symptoms (Table 2). Periodic laboratory nutrient solution analysis is an important proactive tool to detect nutrient disorders earlier than when visible symptoms appear on the plant. In many cases nutrient deficiencies may be due to environmental causes rather than to lack of nutrients in the fertilizer solution. For example calcium deficiency, (i.e. tipburn of lettuce) occurs at high relative humidity and light and temperature conditions that favor fast plant growth.

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Table 1. Control nutrient solution used during the experimental period, single elements were removed to imposed the nutrient deficiencies.

Element	ppm
Nitrogen	210
Phosphorus	31
Potassium	235
Calcium	200
Magnesium	49
Sulfur	64
Iron	4.0
Manganese	0.5
Zinc	0.1
Boron	0.5
Copper	0.10
Molybdenum	0.01

Table 2. Average tissue analysis range of healthy greenhouse butterhead lettuce. Tissue samples taken from most recently mature leaves. (From H.A. Mills and J. Benton Jones, Jr. 1996. Plant Analysis Handbook II. MicroMacro Publishing, Inc.

Macronutrients (%)		Micronutrients (ppm)	
N	4.20-5.60	Fe	168-223
P	0.62-0.77	Mn	55-110
K	7.82-13.68	B	32-43
Ca	0.80-1.20	Cu	6-16
Mg	0.24-0.73	Zn	33-196
S	0.26-0.32	Mo	0.29-0.58

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