e-GRO Research Update
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Symptoms of Common Nutrient Deficiencies in Hydroponic Basil

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In hydroponic production, the fertilizer solution must provide all plant essential elements as a growing substrate is either not present or merely provides physical support and access to water and oxygen. Monitoring plants to look for visual symptoms is an important tool that can be used to detect plant nutrient deficiencies. Basil (Ocimum basilicum) is the most commonly grown hydroponic herb crop. Currently there are few resources in the literature regarding photographs and descriptions of common nutrient disorders in hydroponic basil. Therefore, the objective of this study was to grow sweet basil 'Genovese' in nutrient solutions deficient of individual macro- and micro-nutrients to document visual symptoms of nutrient deficiencies and the timeline and progression of their development.

Materials and Methods

Basil 'Genovese' 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. Each bucket had air bubbled in from plastic tubing with an air stone on the end, which was connected to an aquarium air pump. 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 symptoms of 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.

Summary of Findings

- Our experimental design led to noticeable deficiency symptoms of N, P, K, and Mg on mature leaves. In many cases symptoms progressed over time to recently developed leaves.
- Deficiency of Ca, Fe, and B affected new growth (young leaves).
- S defiency led to uniform chlorosis along leaves, first evident on new growth and eventually affecting the entire plant.

Nitrogen (N)

Nitrogen deficiency resulted in uniform chlorosis (yellowing) of old leaves which was observed after two weeks of deficient conditions (A). Reduced plant size was evident as compared to control plants and mature leaves had severe chlorosis after three weeks (B).

Phosphorus (P)

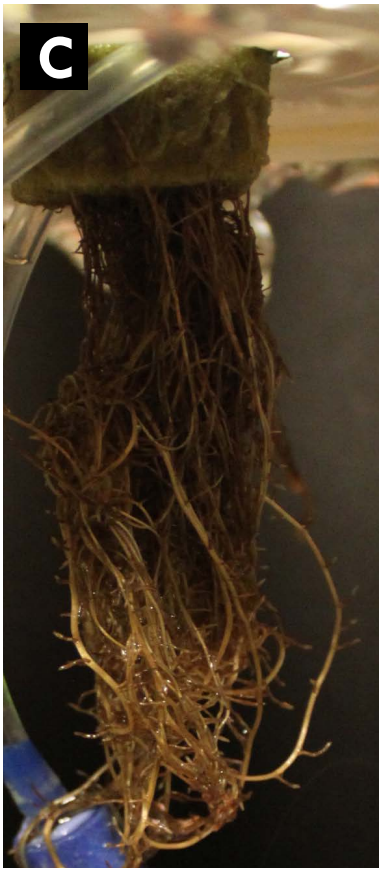
Phosphorus deficiency was first evident as numerous small purple spots on old leaves, evident with three weeks of deficient conditions (A). Overtime, purple regions on lower leaves became larger and also some interveinal chlorosis was evident (B). By week 5 phosphorus deficient plants had flowered earlier than control plants (C).

Potassium (K)

Necrotic spots between the veins of the oldest leaves were noted within two weeks of potassium deficient conditions (A) which became much more pronounced after three weeks (B). After 3-4 weeks of potassium deficiency large chlorotic and necrotic regions along leaf margins and in scattered regions between veins was present (C).

Calcium (Ca)

Symptoms of calcium deficiency began with necrotic spots towards the base of young leaves which was present within three days of deficient conditions (A). Within a week the growing point was dead and necrotic spots had further developed (B). The root system was very noticeably brown (C).

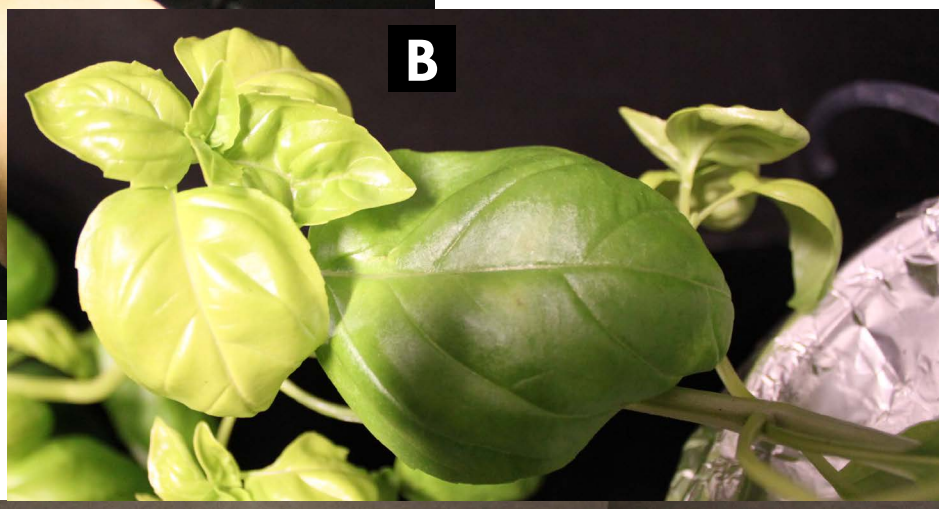


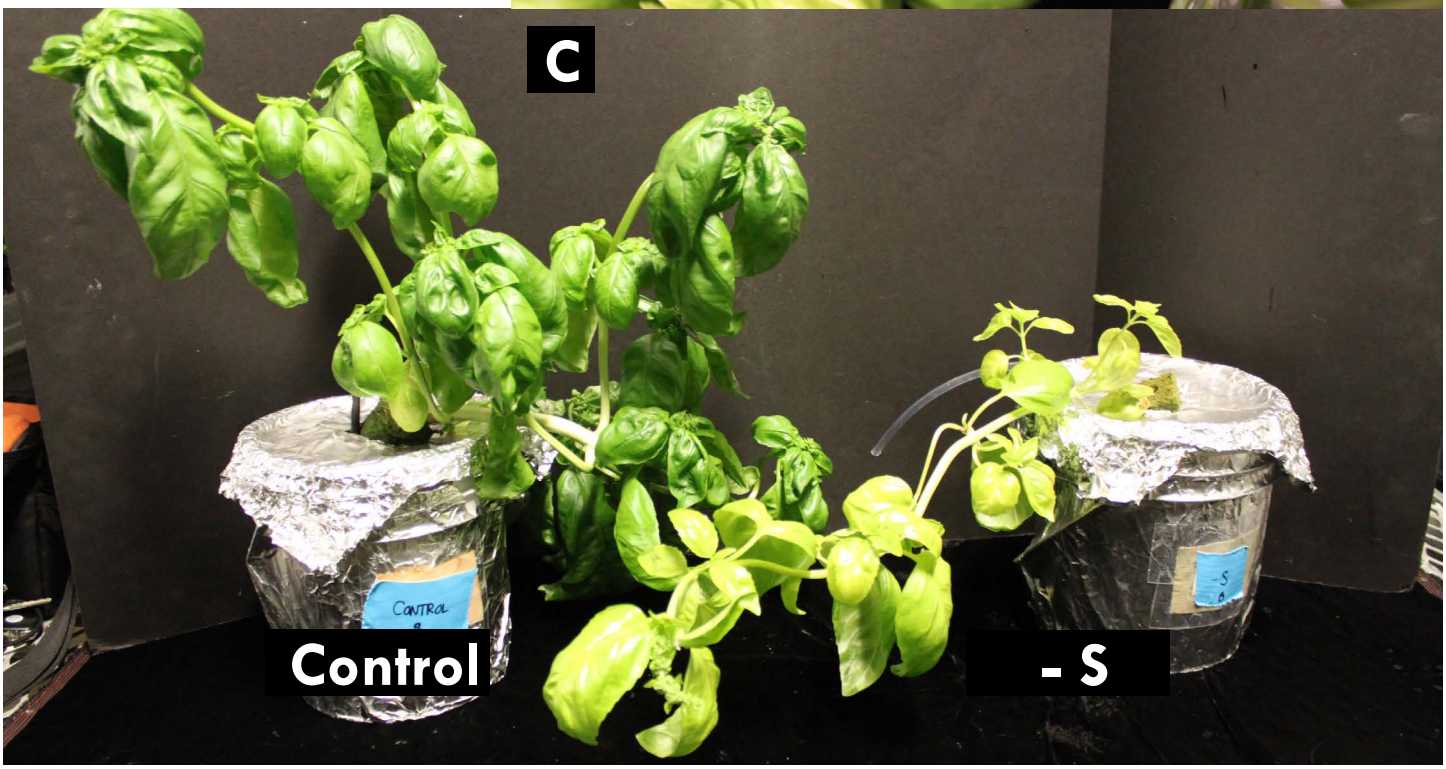
Magnesium (Mg)

Magnesium deficiency presents itself initially as faint interveinal chlorosis of recently mature (middle) leaves which was observed after two weeks of deficient conditions (A). As the deficiency advanced interveinal chlorosis progressed to younger leaves (B), while chlorosis developed into necrotic regions between veins of more mature leaves (C).

Sulfur (S)

Within two weeks of sulfur deficiency, plants exhibited uniform chlorosis across the entire leaf blade and with all leaves on the plant affected (A). The chlorosis became more pronounced over time (B) and plant size was greatly reduced compared to control plants (C).



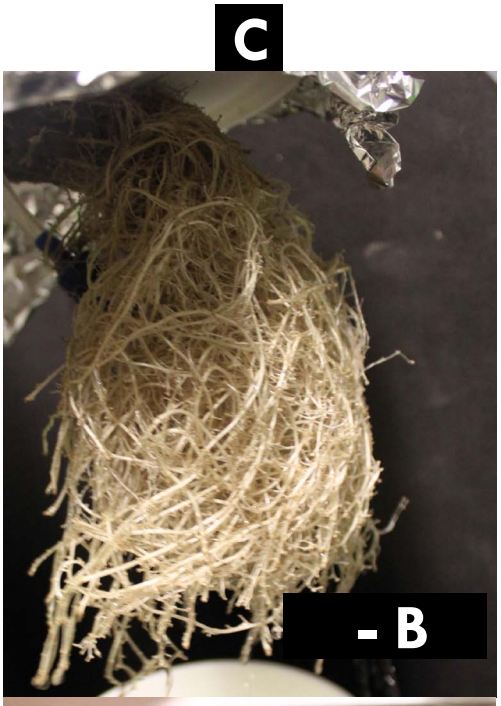


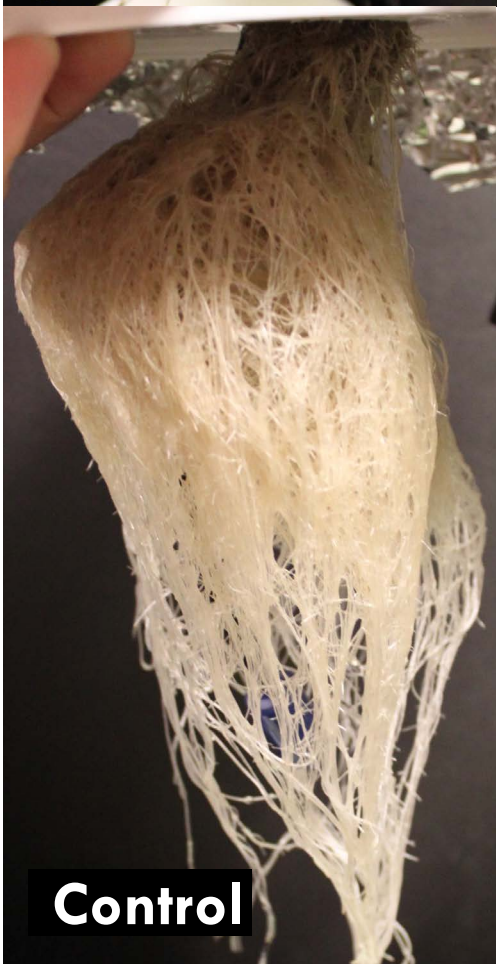
Iron (Fe)

Iron deficiency resulted in interveinal chlorosis of upper (young) leaves (A) while lower leaves remained green (B). In our experiment, symptoms were not observed until 4 weeks of iron deficient conditions.

Boron (B)

Boron deficiency was first evident as faint necrotic regions between the veins on the base of young leaves which was first noticeable after 3 weeks of deficient conditions (A). As the deficiency progressed youngest leaves were distorted/strap-like and young leaves also exhibited interveinal chlorosis (B). The root system was noticeably smaller than control plants with short primary roots and many stubby lateral roots (C).





Discussion

While visual diagnosis is an important tool, it should be noted that many nutrient disorders are similar in appearance. Therefore laboratory leaf tissue analysis is necessary to verify symptoms. Laboratory tissue analysis can help identify a nutritional problem after it has occurred. A more proactive approach, which will help you avoid economic losses from nutritional disorders, is to periodic laboratory nutrient solution analysis. Based on nutrient solution analysis, the fertilizer regime can be modified to ensure adequate supply of nutrients.

It should be noted that the timeline for development of symptoms may vary based on your environmental conditions. In our experiment plants were well-fertilized before we began the initiated the deficient conditions. Therefore the symptoms may have taken longer to develop than if they had been lacking from the beginning. In many cases nutrient deficiencies may be due to environmental or biotic causes rather than to lack of nutrients in the fertilizer solution. For example, high pH (>6.5) reduces solubility of iron, manganese, boron, etc. and can lead to nutrient deficiencies. Disease or insect damage may also look like nutrient disorders. Therefore, the plant must be examined carefully to ascertain the true cause of symptoms.

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

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