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Nutrient disorders of basil

Effectively monitoring and managing nutrient levels in hydroponically grown basil is crucial for maintaining healthy plants and maximizing yields.

This article is the **second** of an **eight-part series** focused on nutrient deficiencies, post-harvest shelf life, disease management, food safety and marketing of culinary herbs produced in controlled environments.

CEA HERB Controlled Environment Agriculture Herb Extension & Research Base

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As part of the Controlled Environment Agriculture Herb Extension and Research Base (CEA HERB) project, our research at NC State University is focused on nutrient disorders. In this article, we will give our attention to basil (*Ocimum basilicum*), as it is one of the most-grown culinary herbs due to its popularity and versatility. Although basil is a warm-season crop, year-round demand necessitates growing it in controlled environments such as greenhouses and indoor farms. Hydroponic systems offer growers the ability to optimize year-round production, but it requires careful monitoring of numerous environmental and nutritional parameters. Beyond pH, electrical conductivity (EC), light and temperature, visually monitoring plants is crucial for early detection of nutrient disorders, which can greatly impact yield and visual quality, leading to unmarketable fresh-cut herbs. Therefore, our goal is to intentionally induce specific deficiencies so that we can identify and document the symptoms of different nutrient deficiencies.

Nitrogen (N), the element needed in the highest quantity, is essential for healthy plant growth and development. It is also a mobile element, and under deficient conditions, it is translocated from the older foliage to support the newest growth. Consequently, a nitrogen deficiency in basil first appears as stunted growth and overall yellowing, known as chlorosis, of the older leaves. Persisting deficiency results in uniform chlorosis of the entire plant, resulting in pale, light-green foliage (**Figure 1**). Under severe deficiency, necrotic patches may appear on the older leaves. With nitrogen being the most utilized element in plants, it is no surprise that this is the most common deficiency observed in basil.

Figure 1. Nitrogen deficiency in basil causes stunted growth and overall pale, light-green foliage.

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Magnesium (Mg) deficiency is a commonly encountered nutritional disorder observed in hydroponically grown basil due to its high require-

Figure 3. Interveinal chlorosis of the newest foliage caused by iron deficiency in basil.

ment for magnesium. Because magnesium is also mobile within the plant tissue, deficiency symptoms are initially evident on the older, lower leaves. An early sign of magnesium deficiency is subtle interveinal chlorosis of the lower leaves, followed by necrotic patches that develop around the leaf margin and progress inward (**Figure 2**). If left unaddressed, faint interveinal chlorosis will progress to the newest growth, and older leaves will become entirely necrotic, eventually abscising. To avoid magnesium deficiency, growers should ensure sufficient magnesium levels and avoid over-supplying potassium (K) and calcium (Ca), which can inhibit magnesium uptake. Additionally, supplemental magnesium applications are needed if adequate concentrations are not naturally present in the irrigation water.

Iron (Fe) deficiency is the most common micronutrient deficiency seen in hydroponically grown crops, so understanding the symptoms is essential for early detection. Unlike magnesium and calcium, iron is immobile within the plant and cannot be moved from older tissue to support the newest growth. If iron is unavailable to the plant, the newest leaves develop interveinal chlorosis, while the veins remain green (**Figure 3**). This coloration may initially be subtle but becomes more prominent as the deficiency persists. While inadequate Fe application can cause deficiency symptoms, other factors should also be considered. Iron availability is highly affected by pH and is unavailable for uptake at high pH levels, typically above 6.5.

Potassium (K) is another macronutrient needed in higher quantities. Under potassium-deficient conditions, basil plants exhibit stunted growth and interveinal chlorosis of the older foliage, which progresses to the newer growth over time. The foliage also takes on a downward growth pattern, creating a distinct "umbrella" effect that is typical of potassium deficiencies (**Figure 4**). While symptoms can be confused with magnesium

Figure 2. Magnesium deficiency in basil causes necrotic patches that develop around the leaf margin and progress inward.

Figure 5. Calcium deficiency in basil plants results in curled or "cupped" foliage, necrotic margins and death of the growing points.

Figure 6. Boron deficiency in basil plants causes interveinal chlorosis of the upper foliage, brittle leaves and stems, and necrosis of the growing point.

Figure 4. Potassium deficiency in basil plants causes stunted growth, chlorosis of the older leaves and a downward growth pattern.

deficiency, a potassium deficiency is usually less likely to occur because adequate K is supplied in most fertilizer programs.

Calcium (Ca), another immobile nutrient, plays an important role in the membranes and cell walls of plants. In the case of a calcium deficiency, the newest leaves on basil plants develop marginal chlorosis followed by necrosis, resulting in cupped leaves that are unable to fully expand. With advanced symptomology, the growing points will die, causing dramatic distortion of the upper foliage (**Figure 5**).

Boron (B) is a micronutrient that shares some similarities with calcium due to its role in cell wall development but is needed in much smaller quantities. Symptoms of boron deficiency include distorted growth, interveinal chlorosis and brittle leaves and stems. Similar to calcium-deficient plants, the newest growth on boron-deficient basil plants exhibit a downward, cupped appearance, with necrotic patches developing on the leaf margins. If deficiency persists, the growing points can also become necrotic (**Figure 6**). While it can initially be mistaken for calcium deficiency, boron deficiency is unique due to the thick and brittle upper foliage that it causes.

Although inadequate fertilization can be a definite cause for nutrient deficiencies in basil, other factors, such as pH imbalances, environmental conditions and nutrient interactions, can also play a role. For instance, extreme temperatures can stress plants and reduce their ability to effectively absorb nutrients.

Similarly, nutrient interactions, particularly antagonistic interactions, also inhibit nutrient uptake. This occurs when one nutrient is in excess and as a result blocks the uptake of another essential nutrient. For example, excess potassium can block the uptake of magnesium and calcium, resulting in a deficiency despite adequate fertilization. Further, a high pH can reduce the availability of micronutrients, especially iron.

These factors should all be considered when addressing nutrient disorders to effectively get to the root of the problem. Often, taking tissue and nutrient solution samples for analysis can also help confirm a diagnosis.

Effectively monitoring and managing nutrient levels in hydroponically grown basil is crucial for maintaining healthy plants and maximizing yields. Recognizing the symptoms of common nutrient deficiencies can help growers assess the health of their basil crop, enabling them to detect and correct problems before they severely impact basil quality and marketability. **pg**

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