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Magnesium Deficiency of Hydroponic and Container Grown Basil

Basil (*Ocimum basilicum*) is the most commonly grown greenhouse herb crop. Basil is sensitive to magnesium deficiency. Visual symptoms of magnesium deficiency appear first on old and recently mature leaves as a slight interveinal chlorosis (yellowing). This article will cover the progression of visual symptoms of magnesium deficiency, common causes of the deficiency, target leaf tissue elemental magnesium, and corrective actions for both hydroponic and container grown plants.

Magnificent Magnesium

Magnesium (Mg), is an essential plant nutrient. As a macronutrient, Mg is required in relatively large amounts.



Figure 1. Interveinal chlorosis on mature and recently mature leaves of basil is an early symptom of magnesium deficiency. Roots Photo: © Neil Mattson, Cornell University

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On average, plants require Mg in greater quantity than all other elements except nitrogen (N) and potassium (K). Magnesium is a central building block to chlorophyll, the pigment that makes plants appear green and the molecule responsible for capturing lighting in photosynthesis. Magnesium is also involved in several key enzymes related to carbohydrate metabolism and in protein synthesis. Suffice it to say, plants cannot function properly without enough magnesium.

Visual Symptoms

Magnesium deficiency presents itself initially as slight/faint interveinal chlorosis (yellowing between the leaves) of mature recently mature and mature leaves (Figure 2). In our own studies withholding Mg from the nutrient solution, visible symptoms were present after two weeks. As the deficiency advances, marginal chlorosis (yellowing along the edges of the leaves) is present and the interveinal/marginal chlorosis progresses to younger leaves (Figure 3). On more mature leaves the chlorosis progresses into necrotic patches both along the leaf margin and as irregular necrotic blotches within the leaf (Figure 4). The necrotic regions can take on a reddish brown hue.



Figure 2. Symptoms of magnesium deficiency of basil include interveinal chlorosis on mature leaves. © Neil Mattson, Cornell University



Figure 3. As magnesium deficiency progresses, younger leaves can be affected and marginal chlorosis is present. Photo: © Tanya Merrill, Cornell University



Figure 4. In advanced stages of magnesium deficiency of basil, leaf marginal necrosis and irregular necrotic blotches on mature leaves are present. Photo: © Tanya Merrill, Cornell University



Figure 5. Hydroponic basil with interveinal chlorosis from iron deficiency. Notice that young leaves are affected while mature leaves are not. Photo: © Tanya Merrill, Cornell University



Figure 6. Basil with early potassium deficiency showing slight marginal necrosis and necrotic spots across the leaf interior (A) and dull yellow leaves with papery necrotic blotches in a more advanced stage (B). Photo: © Tanya Merrill, Cornell University

Visual symptoms of Mg deficiency can appear somewhat similar to other deficiencies. For example, iron (Fe) deficiency also appears as interveinal chlorosis. However with iron deficiency young (immature) leaves are affected first (Figure 5). Potassium (K) deficiency of basil appears initially as faint necrotic regions between the veins of the oldest leaves (Figure 6A). As potassium deficiency symptoms progress, leaves can take on a dull yellow color with large papery necrotic regions (Figure 6B). For more information on symptoms of other nutrient deficiencies of basil, see a previous e-Gro Research Update at: <https://e-gro.org/pdf/2016-4.pdf>

Because different nutrient disorders are similar in appearance, it is important to use laboratory leaf tissue analysis to verify the cause. Table 1 lists the sufficiency range (minimum and maximum values) for mineral elements in basil as compared to lettuce. Note that basil Mg requirements (tissue concentration) are about twice as high as lettuce.

Causes of Mg Deficiency

The most common cause of Mg deficiency is that the supplied Mg (either from the fertilizer or water supply) is insufficient. Many water sources with high alkalinity naturally contain calcium (Ca) and Mg. Therefore common acidic fertilizers for container grown plants in high alkalinity water do not contain Mg. These fertilizers contain a portion of the N as ammoniacal N (to help acidify the root zone); examples include: 20-20-20, 20-10-20, and 21-5-20. However, the water source may end up not having sufficient Mg supply, thus necessitating Mg from another source. Potting mixes usually contain an initial dose of Mg added in the form of dolomitic limestone. However, over time the initial Mg can run out.

	Basil sufficiency ranges		Lettuce sufficiency ranges	
	min	max	Min	max
N %	3.5	4.2	2.8	4
P %	0.3	0.75	0.3	0.95
K %	2	4	2.0	8.0
Ca %	1	2.2	0.5	2
Mg %	1	1.8	0.5	0.8
S %	---	---	0.25	0.4
Fe ppm	150	375	50	300
Mn ppm	50	250	20	200
B ppm	15	40	20	55
Zn ppm	20	35	30	150
Cu ppm	5	20	5	80
Mo ppm	0.2	1	0.06	0.15

Table 1. Sufficiency ranges for elemental tissue analysis of basil and lettuce. Adapted from: Dr. Cari Peters, J. R Peters Laboratory. 6656 Grant Way, Allentown, PA 18106; and Adapted from: Jones, J.B. Jr., W. Wolf and H.A. Mills. 1991 Plant analysis handbook. Micro-Macro Publications, Inc. 185 Paradise Blvd, Suite 108, Athens, GA 30607

ppm	Basil	Lettuce
N (total)	150	130
NO ₃ -N	135	120
NH ₄ -N	10-15	10
Urea	0	0
P ₂ O ₅	25-35	25-35
K ₂ O	125	100
Ca	80	80
Mg	40	40
S	100-300	100-300
Fe	2-3	1.5-2
Mn	0.75-1.0	0.75-1.0
B	0.25	0.25
Zn	0.25	0.25
Cu	0.15	0.15
Mo	>1	>1
pH	5.8	5.8

Table 2. Target nutrient concentration for hydroponic nutrient solutions of basil and lettuce. Adapted from: Dr. Cari Peters, J. R Peters Laboratory. 6656 Grant Way, Allentown, PA 18106

For hydroponic production, Mg, is one of the essential elements present as part of a complete hydroponic nutrient solution. However, again, Mg supply may be lower than plant demand. This is particularly true for basil, which based on tissue analysis, appears to require a greater concentration of Mg than leafy greens. Hydroponic nutrient solutions are typically maintained so as to hold a constant electrical conductivity (EC). However, nutrient imbalances can occur over time. For example, while EC may remain constant, particular nutrients may be consumed quicker than they are added (ex: Mg) while other nutrients may accumulate. Therefore, while EC may be constant (suggesting sufficient fertility) but in actuality some nutrients will be in low supply while others are in high supply. Nutrient imbalances can also exacerbate Mg deficiency. For example, excessively high Calcium (Ca) or Potassium (K) can inhibit Mg uptake. A typical target is a ratio of 2:1 Ca:Mg and 4:1 K:Mg, greater amounts of Ca or K can reduce Mg uptake. A couple of less common causes of Mg deficiency are low root-zone temperature or a poorly developed root system due to disease or water logging. Such root disorders can lead to insufficient nutrient uptake. Low substrate pH can also contribute to Mg deficiency as Mg is poorly available at low pH (ex: pH less than 5).

Corrective Procedures

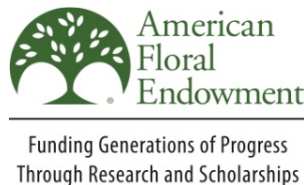
The primary corrective procedure is to ensure that adequate Mg is available either from the water supply or from the fertilizer. As shown in table 2 the target concentration for Mg in basil and lettuce hydroponic nutrient solutions is about 40 ppm. Since basil appears to have a higher Mg tissue concentration, I prefer to aim for 60 ppm Mg when I prepare nutrient solutions specifically for basil. Mg is typically added in the form of MgSO₄ (specifically MgSO₄•7H₂O, i.e. Epsom salts) (Table 3).

For container grown plants, a monthly corrective drench can be applied at a rate of 1-2 pounds of MgSO₄ (Epsom salts) per 100 gallons of water (i.e. 120-240 grams per 100 Liters of water). Alternatively, switch to a Mg containing complete water soluble fertilizer, or add MgSO₄ to your daily fertigation program. Again, MgSO₄ is used with a typical target of 40 ppm Mg for most container plants or 60 ppm Mg for basil plants. Remember that MgSO₄ cannot be added to the same concentrated stock tank as fertilizers containing calcium nitrate (CaNO₃) because a precipitate will form (rendering the fertilizer insoluble and clogging your injector). In dilute form, such as in a hydroponic pond or NFT reservoir, there are no incompatibility issues.

Remember, for both hydroponic and container plants, it is important to be proactive regarding magnesium. First, make sure you have a current elemental water analysis from a laboratory so you know how much Mg is already available in your water source. Once you know your water source Mg concentration you can determine how much additional Mg you need to add in the fertilizer to reach the Mg target. Periodically have the hydroponic nutrient solution (or the substrate in container production) tested by an analytical lab to identify any nutrient deficiencies or imbalances.

Magnesium Sulfate MgSO ₄ •7H ₂ O (Epsom salts) 9.86% Mg, 12.9% S					
Target ppm Magnesium	10	20	40	60	100
g Epsom salts / 100 Liters water	10.14	20.28	40.57	60.85	101.42
oz. Epsom salts / 100 gallons water	1.36	2.71	5.43	8.14	13.56
oz. Epsom salts / 1 gallon of stock (1:100 injector)	1.36	2.71	5.43	8.14	13.56
oz. Epsom salts / 1 gallon of stock (Hozon 1:16)	0.22	0.43	0.87	1.30	2.17
ppm S supplied by MgSO ₄ •7H ₂ O	13.08	26.17	52.33	78.50	130.83

Table 3. Quantity of magnesium sulfate required to reach a target Mg concentration.



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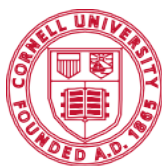
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