Magnesium

ESSENTIAL ELEMENTS

THE FERTILIZER INSTITUTE

Magnesium (Mg) is one of nine macronutrients and is taken up by plants in quantities similar to that of phosphorus (P).

Magnesium in Plants

In plants, Mg is essential for many functions. It:

- sets in motion (catalyzes) the production of chlorophyll and serves as the central atom in the chlorophyll molecule;
- serves as a building block of ribosomes, the "factories" that synthesize proteins in cells;
- stabilizes certain structures of nucleic acids, the molecules that transfer genetic information when new cells are formed;
- activates or promotes the activity of enzymes, which are molecules that have specific shapes needed to set in motion certain chemical reactions necessary for proper growth and development of plants;
- serves as an essential element to create adenosine triphosphate (ATP), the "battery" that stores energy in the plant;
- ensures carbohydrates created in leaves are exported to other plant organs. Carbohydrates are used in plants for energy and for structure.

Magnesium in Soils

Plants can only access Mg in the soil solution. Contributors to this Mg are:

- redistribution from other areas, including: irrigation water, commercial fertilizer, manure, biosolids, and sediment deposition;
- weathering of Mg-containing primary and secondary minerals like certain types of amphiboles, biotite, chlorites, dolomite, garnets, olivine, magnesite, phlogopite, some pyroxenes, serpentines, talc, and tourmaline;
- release from the interlayers of the layer silicate minerals chlorite, smectites, and vermiculite; and
- release (desorption) from surfaces and edges of layer silicate minerals, termed "exchangeable Mg."

Exchangeable Mg and Mg in the soil solution are the Mg forms measured by soil tests and are considered readily available to plants.

Minerals containing Mg are more soluble in acid soils (below pH 7). In sandy soils with low numbers of exchange sites (low cation-exchange capacity), dissolved Mg can move below the root zone because there are not enough edges and surfaces of layer silicate minerals to retain it in the upper levels of the soil. Therefore, levels of exchangeable Mg in acid, sandy soils can be too low to meet plant nutritional needs.

When plant roots take up water, more water from farther away moves to the roots to replace that which was taken up. Magnesium that is dissolved in the soil solution moves with this water. This process, termed mass flow, is responsible for keeping the plant supplied with dissolved Mg.

Fertilizing Soils with Magnesium

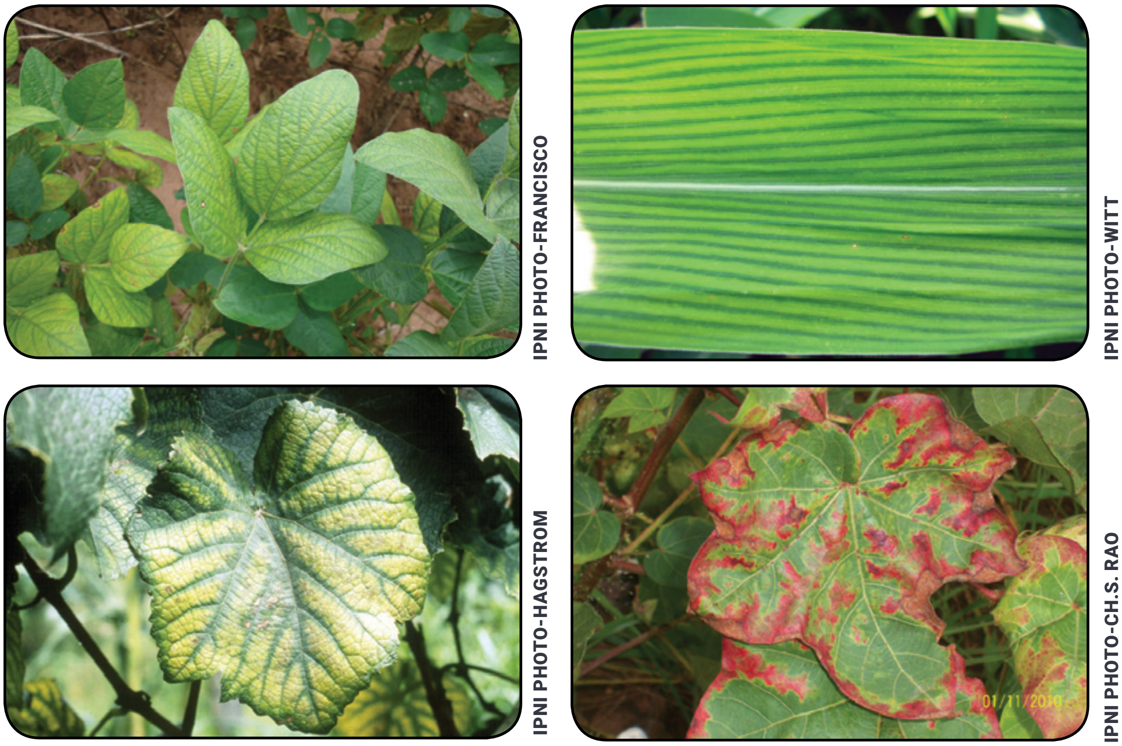
Fertilizing soils with Mg is necessary when the soil alone cannot supply enough to meet crop needs. Soil testing is used to assess soil Mg supplies that are available to plants. Many other nutrients can compete with Mg for crop uptake (termed antagonism). In acid soils, aluminum (Al), the hydronium ion (H^+), and manganese (Mn) can reduce Mg uptake by plants. In basic soils, calcium (Ca) and sodium (Na) compete for Mg uptake. Where higher rates of ammonium (NH^{4+}) forms of nitrogen have been applied, either with fertilizers or manures, Mg levels in plants can be lower. The same effect occurs where higher rates of potassium (K) have been applied or where soils are naturally high in K, such as in arid regions of the U.S. These antagonisms are most likely to occur where soil Mg levels are marginal.

Many fertilizer sources of Mg are available. **Table 1** lists these sources and their average Mg concentrations, which range from

Table1. Commercial sources of magnesium fertilizer[1].

Fertilizer name	Chemical formula	Typical Mg concentration, %
Dolomite	$MgCO_3 . CaCO_3$	6 - 20
Hydrated Dolomite	$MgO . CaO/MgO . Ca(OH)_2$	18 - 20
Kainite	$MgSO_4 . KCl . 3H_2O$	9
Kieserite	$MgSO_4 . H_2O$	17
Langbeinite	$2MgSO_4 . K_2SO_4$	11
Magnesium Chloride	$MgCl_2$	25
Magnesium Nitrate	$Mg(NO_3)_2 . 6H_2O$	9
Magnesium Oxide	MgO	56
Magnesium Sulfate	$MgSO_4 . 7H_2O$	9
Schoenite	$K_2SO_4 . MgSO_4 . 6H_2O$	6
Struvite	$MgNH_4PO_4 . 6H_2O$	10

This information was originally developed by the International Plant Nutrition Institute.



Magnesium deficiency (clockwise order starting top left) in soybean, corn, grape, and cotton. It commonly starts as interveinal chlorosis on leaf margins, spreading towards the center of the leaf as conditions worsen. Tissue become bright yellow between the veins, and finally can become reddish purple from the outside leaf edges inward.

6 to 56 percent. Dolomite and hydrated dolomite are used most commonly to correct Mg deficiencies while simultaneously raising soil pH levels in acid soils.

Either soil or foliar applications of Mg may be recommended, depending on the crop to be grown and the growth stage when Mg deficiency is diagnosed. Foliar applications are sometimes recommended for forage crops where Mg concentrations in plant tissues are too low for animal nutrition, which can lead to grass tetany, or hypomagnesemia. Foliar applications must usually be repeated since Mg is taken up in large quantities.

Magnesium Deficiency Symptoms

When plants don't have enough Mg, an important process gets inhibited. During photosynthesis, carbohydrates are produced. The plant uses these carbohydrates for energy and also for structure. When Mg is deficient, the movement of carbohydrates from the leaves to other parts of the plant is slowed. This results in reduced growth of other plant organs like roots and the reproductive parts that are harvested. Reduced root growth can inhibit the uptake of other nutrients that the plant needs, causing a cascade of nutritional problems. Additionally, the buildup of carbohydrates in the leaves signals the plant to slow down photosynthesis and produce fewer carbohydrates—just the opposite of what a growing plant needs. Stunted plants and smaller root systems are the result. The inhibition of photosynthesis produces an interveinal yellow appearance to leaves, usually most prominent on the older leaves on the plant.

Crop Response to Magnesium

When plants are deficient in Mg, adding more Mg results in increased Mg concentrations in plant tissues and can also lead to increased growth and yield. The ratio of Mg to K and Ca in plant tissues can be an important issue for forages. **Table 2** provides an example of a crop response to Mg fertilization. Grain sorghum was grown on an acid, sandy loam soil that was low in Mg. Adding Mg increased sorghum grain yield 15 to 29 percent, depending on the rate applied. The numbers in the table are averages over three different hybrids and three study years. This study reinforces that Mg is an essential nutrient and is required for proper plant growth.

Table 2. Sorghum grain yield response to magnesium fertilization[2].

Mg rate, lb/A	Average grain yield, bu/A	Percent yield increase, %
0	75	--
15	86	15
30	86	15
45	94	25
60	97	29

References

1. Mikkelsen, R. 2010. Better Crops 94(2):26-28.
2. Gallaher, R.N. et al. 1975. Agron. J. 67:297-300.

Further Reading

Gerendás, J. and H. Führs. 2013. Plant Soil 368:101-128.

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