Essential Secondary Elements: Magnesium
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Cooperative Extension Service
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Extension Specialist in Crop and Soil Sciences
August 1979
4 pages

COOPERATIVE EXTENSION SERVICE
MSU AG FACTS

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Extension Bulletin E-994 August 1979

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PLANTS AND ANIMALS do not grow normally without ample magnesium (Mg). Deficiencies of Mg have been diagnosed in Michigan in both plants and animals. Therefore, care should be exercised so that yield and quality are not limited by shortages of this element.

Magnesium, along with calcium (Ca) and sulphur (S), is classed as a *secondary plant element* because it is used in much smaller quantities than the major elements but in larger amounts than the micronutrients.

Magnesium in Animals

Magnesium is a part of every animal cell. Its primary source is in foods of plant origin. Natural toxicities from this element are not recognized, while on occasion deficiencies occur. With scientific feeding programs, deficiencies are not likely.

"Grass Tetany" and "Grass Staggers" in lactating cows are common names for acute Mg deficiency. Animals showing such symptoms have low Mg levels in the blood serum. When affected animals are injected with Mg, recovery frequently occurs within a few minutes.

Maintaining an adequate daily supply of Mg is the best known method of preventing deficiencies in animals.

Magnesium in Plants

Magnesium is also a part of every plant cell. It is an integral part of chlorophyll—the green pigment in field crops—making it essential for photosynthesis. Enzyme systems involved in energy transfer and respiration do not function properly with low Mg levels.

The Mg content of different crops varies, as reported in Table 1. Legumes tend to contain more Mg than the grasses except corn. Mg levels in grains are generally higher than Ca levels, while the reverse is the case for other plant parts.

Obviously, Mg requirements are related to yields. Because Mg levels in seed are relatively low, where only grain is harvested some time is required to reduce soil Mg levels significantly.

Evaluation of the Mg status in plants can be made by chemical analyses. Plant tissue analyses are available through several laboratories. The percent Mg values in Table 2 represent the "sufficiency range,"

Table 1. Typical Magnesium Levels in Select Crops.[1]

Crop	*Yield*	*Mg content (pounds)*
Alfalfa hay	4 T	21
Barley grain	80 Bu	4
Barley straw	2 T	4
Corn grain	150 Bu	8
Corn stover	4.5 T	20
Wheat grain	60 Bu	8
Wheat straw	2.0 T	4
Soybean seed	40 Bu	7
Navy bean seed	40 Bu	6
Sugar beet root	20 T	28

[1]*Calculated from several sources.*

Table 2. Magnesium Sufficiency Ranges[1] (based on plant tissue analysis).[2]

Crop	*Sampling notes*	*Sufficiency range percent*
Corn	Ear leaf immediately before silking	0.16-0.60
Soybeans	Upper mature leaf just before flowering	0.26-1.00
Alfalfa	Top growth—6 inches to flowering	0.31-1.00
Wheat	Upper leaves prior to initial bloom	0.21-1.00
Sugar beets	Center mature leaf at mid season	0.36-1.00
Vegetables	Top fully developed leaf	0.25-1.00
Potatoes	Petioles from newly matured leaf at mid season	0.17-0.22

[1]*Levels necessary for high crop yields.*
[2]*From M.S.U. Ext. Bul. E-486 (1973).*

which defines a level necessary for high crop yields. Lower levels imply yield-restricting deficiencies, while higher levels a nutrient imbalance.

The information in Table 2 can be used most easily when samples are collected at the time indicated. Also interpretation of data is difficult when other plant parts are collected. While the sufficiency range concept is a valuable tool for diagnosing plant nutrition problems, experience has shown that the values are best used as guidelines. Soil testing provides supplemental information which aids in the evaluation of plant tissue tests.

On occasion, Mg deficiencies may be diagnosed by interpreting plant nutrient deficiency symptoms. With this method, care must be exercised so that insect, disease, air pollution and soil acidity effects are not confused with the deficiency symptoms. Plant tissue and soil analysis aid in interpreting nutrient dificiency symptoms.

Magnesium deficiency symptoms have been observed in Michigan on cauliflower, celery, corn, greenhouse tomatoes, mushrooms, oats, potatoes, peas and rye.

Symptoms of Mg deficiency generally develop first on the older leaves. The first symptom is a loss of a healthy, green color between veins. This is followed by a chlorosis (yellowing) and sometimes the development of pink or purple colors. Chlorosis starts on the leaf margins and progresses inward interveinally. While deficiency symptoms show most frequently on small plants, they usually develop too late for any remedial treatment. If such characteristics show where plant tissue and soil tests are low, it is relatively certain that the symptoms truly reflect Mg deficiencies.

Magnesium in Soil

Magnesium is a component of several primary and secondary soil minerals which are relatively insoluble. It also occurs in solution as an ion[1] and on the surface of both mineral and organic colloids.[2] When adsorbed onto the surface of colloids, the Mg is referred to as "exchangeable."

Most exchangeable Mg is available to plants and represents residual quantities of naturally occurring Mg plus that added to the soil in the management process. The Mg of the primary and secondary minerals is relatively insoluble and, therefore, relatively unavailable to plants. This illustrates why total soil Mg is not closely related to plant growth.

Quantities of exchangeable Mg vary greatly between kinds of soil and also within soil profiles, as reported in Table 3. The naturally well-drained "a" soils contain much less exchangeable Mg than the somewhat poorly drained "b" and the poorly drained "c" soils. Also, the sandier soils contain less Mg than the fine-textured soils. This partially explains why Mg deficiencies occur most frequently on well-drained, sandy soil. In general, when tests show more than 75 pounds per acre, the soil contains sufficient Mg for high crop yields.

Table 3. Average Magnesium Levels in the Profiles of Soils Used for Corn Production in Michigan.[1]

			Natural drainage class		
			(a)	*(b)*	*(c)*
Dominant profile texture	*Soil group symbol*	*Soil profile symbol*	*Well drained*	*Somewhat poorly drained*	*Poorly drained*
			Pounds/acre		
Clay and clay loam	1 & 1.5	A	500	800	1,000
		B	900	1,600	1,050
		C	650	1,600	950
Loam and sandy loam	2.5 & 3	A	300	450	900
		B	400	600	650
		C	350	350	400
Loamy sand and sand	4 & 5	A	65	300	350
		B	60	125	80
		C	60	125	150

[1]*For more details, see M.S.U. Agr. Exp. Sta. Res. Rpt. 286.*

Some agronomists, not familiar with field research in the Great Lakes area, place strong emphasis on producing an ideal calcium:magnesium (Ca:Mg) ratio. Both field research and numerous observations show that soil Ca:Mg ratios can be greatly altered by using high rates of Ca or Mg. Changing Ca:Mg ratios does *not* affect crop yields even with wide ratios *if the pH is within a reasonable range*. Therefore, gypsum or high Ca limestone is not recommended for increasing Ca levels or altering Ca:Mg ratios. Furthermore the use of dolomitic lime on low Ca and high Mg soils will not cause a Mg toxicity as theorized by some.

Also some agronomists feel that potassium (K) levels within a plant are likely to be affected by wide ranges in Ca:Mg ratios, especially when created by applied Ca or Mg. In field research on both alfalfa and corn, plant K levels were not changed by the use of Ca or Mg.

Fertilizer recommendations for Mg are currently made when, as a percent of the total bases (Mg + Ca + K, expressed as milliquivalents), the K levels exceed Mg or when soil Mg, as a percent of total basis, is less than 3% or when soil tests are less than 75 pounds per acre.

[1]*Ion—an electrically charged form of the element.*

[2]*Colloid—matter having very small (submicroscopic) particle size and a correspondingly high surface area per unit of mass.*

Magnesium in Water

Water represents a potential source of Mg, provided that enough water is used. River water in Michigan ranges between 5 and 28 ppm. Water in the southern part of the state is likely to contain more Mg than in the northern (Table 4). If, during the season, 12 inches of irrigation water are used, it should contain sufficient Mg to take care of the Mg requirements of one crop.

Lake and pond water frequently contain less Mg than river water, primarily because Mg compounds easily precipitate out of solution. Well water also contains variable quantities of Mg. Therefore, where there is concern about maintaining soil Mg levels with irrigation water, chemical analysis of the specific source is advised.

Table 4. Magnesium Content of Select River Water.[1]

River	*County*	*Average magnesium level* ppm	*Pounds/ acre foot*
Sturgeon	Houghton	4.8	13
Escanaba	Delta	8.0	22
Pine	Charlevoix	12.0	33
Elk	Antrim	12.0	33
Cheboygan	Cheboygan	14.5	39
Thunder Bay	Alpena	14.0	38
Flint	Saginaw	24.0	65
Cass	Saginaw	28.0	76
Rouge	Wayne	13.0	35
Raisin	Monroe	25.0	68
St. Joseph	Berrien	21.5	58
Grand	Ottawa	24.0	65
Muskegon	Muskegon	14.5	39

[1]*From Michigan Department of Natural Resources, Bureau of Water Management.*

Magnesium in Livestock Manure

While the Mg level in livestock manure is variable, it is a good source of Mg, as shown in Table 5. The use of 10 tons per acre of any well-conserved manure should meet the minimal requirements for any one crop.

Table 5. Average Magnesium Content of Livestock Manure.[1]

Kind of manure	*Tons of manure* 1	5	20
Chicken—No litter	5.8	29.0	116.0
Chicken—Floor litter	2.4	12.0	48.0
Dairy cows	2.2	11.0	44.0
Fattening cows	2.0	10.0	40.0
Hog	1.6	8.0	32.0
Horse	2.8	14.0	56.0
Sheep	3.7	18.5	64.0

[1]*Calculated from several sources.*

As with water, the use of manure represents one way of meeting the minimal crop requirements. At high rates, soil Mg levels may increase sligthly; however, with the way manure is used today, increases in soil test levels are not expected.

Magnesium in Municipal Sludges and Waste Waters

Recent analysis of 40 samples of sludge from several municipalities in Michigan shows that Mg levels varied between 0.14 and 1.02 percent, which is equivalent to 2.8 and 20.4 pounds per dry ton. Therefore, where there is interest in using sludges as a source of Mg in crop production, chemical analysis of representative samples is urged.

Waste water effluents represent another potential source of Mg. A recent summary of waste water discharged from 58 Michigan municipalities ranged between 6.6 and 38.1 ppm. This is equivalent to 18 and 103 pounds of Mg per acre foot of effluent.

Magnesium Carriers

The most common carriers of Mg used in Michigan are shown in Table 6. Such materials represent the cheapest and the most concentrated materials available for crop production.

Dolomite and magnesium oxide are much less soluble than other materials. These should be used sometime before a crop is planted. For more information on dolomite, refer to MSU Extension Bulletin 471—"Lime for Michigan Soils."

Table 6. Magnesium Carriers—Sources of Mg.[1]

Carriers	*Formula*	*Percent Mg*
Inorganic		
Dolomite	$MgCO_3 + CaCO_3$	11
Epsom salt	$MgSO_4 \cdot 7H_2O$	10
Kieserite, calcined	$MgSO_4 \cdot H_2O$	18
Magnesia	MgO	55
Potassium—magnesium sulfate	$K_2SO_4 \cdot 2MgSO_4$	11
Organic		
Reax Magnesium	MgMPP	4-9
THIS Magnesium	MgMPP	4

[1]*From Fertilizer Handbook (The Fertilizer Institute).*

Synonyms

1. $MgCO_3 + CaCO_3$, dolomite, dolomitic lime, dolomitic limestone, magnesium limestone.
2. $MgSO_4 \cdot 7H_2O$, Epsom salt, magnesium sulphate.
3. MgO, magnesia, magnesium oxide, oxide of magnesium.
4. $K_2SO_4 \cdot 2MgSO_4$, potassium magnesium sulphate, sulphate of potash magnesium, double manure salt, *Sul-PO-Mag.*

Magnesium Recommendations

Where there is need to supply Mg in crop production processes, use:

1. Dolomitic lime on acid soils. As little as 1,000 pounds per acre will correct all magnesium deficiencies.
2. On nonacid soils, soluble forms of Mg, such as Epsom salts, sulfate of potash magnesia, or finely ground magnesium oxide. Rates which supply 10 to 25 pounds Mg per acre in the row or 50 to 100 pounds broadcast are satisfactory.
3. For foliar feeding, 10 to 20 pounds of Epsom salts in 30 gallons of water for each acre. Apply when plant stress is low: early in the morning or evening.

Summary

Mg is an essential element for both animals and plants. It is not required in large quantities. Mg deficiency is not likely in well managed animals.

In plants, Mg deficiencies can occur on acid, coarse-textured soil. Diagnosing need to use Mg can be done with soil tests, tissue tests, and by the evaluation of Mg deficiency symptoms. The best way to prevent Mg deficiencies is to test the soil regularly and systematically.

Most soil contains ample Mg for optimum yields. When extra Mg is required, dolomite is an inexpensive, good source for acid soils. Irrigation water and livestock manure contain ample Mg to meet short-term requirements.

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