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All soils contain calcium ions (Ca^{2+}) and magnesium (Mg^{2+}) cations (positively charged ions) attracted to the negative exchange sites on clays and organic matter (cation exchange complex of the soil). The amount and relative proportion usually reflect the soil's parent materials. Calcium (Ca) and Mg are plant-essential nutrients, and the ionic form of each held on the soil exchange sites is the form taken up by plants. The usual approach for determining whether the soil supply is sufficient to meet crop needs is to extract soil with 1 molar (M) ammonium acetate (the same procedure used to determine soil test potassium) and evaluate the amount measured against critical levels. Because Iowa soils contain more than adequate levels of these nutrients, no critical level has been or can be established. Therefore, exchangeable Ca and Mg are not routinely tested, nor are there Iowa State University publications that give soil test Ca or Mg interpretations. Unless you are interested in the soil cation exchange capacity (CEC)--in routine soil testing determined by summing the dominant exchangeable cations (Ca^{2+}, Mg^{2+}, K^+, H^+)--soil samples don't need to be analyzed in the laboratory for Ca and Mg from most Iowa fields. Also, Iowa soils have large quantities of both nutrients and they are replenished by limestone application.

How is a Ca:Mg ratio calculated?

Once exchangeable Ca and Mg are determined by laboratory analysis, the ratio is calculated using the meq basis (electrical charge basis). For example, if there is 4.88 meq Ca/100 g soil and 1.72 meq Mg/100 g, then the Ca:Mg ratio is 2.8:1. Table 1 gives the exchangeable Ca, Mg, and calculated Ca:Mg ratio for several Iowa soils. These values are typical for Iowa soils. Soil Ca:Mg ratios naturally are above 1:1.

Why the interest in Ca:Mg ratios?

Good question. From the above-mentioned statement that Ca and Mg levels are higher than needed for crop production in Iowa soils, you can easily conclude that ignoring the ratio is just fine. Research confirms that this conclusion is justified; however, promotion of the ratio concept persists today despite many years of research that indicates otherwise. The origin of this concept was derived from work by Bear and colleagues in the 1940s. However, their work did not differentiate between crop response (alfalfa) due to pH improvement from lime application to acid soils and the change in Ca:Mg. Other research during the same time indicated that ratios were not important. Many research trials since have not shown an influence of Ca:Mg ratio on crop production. An example is work by McLean and colleagues in 1983 in which ratios were manipulated by application of calcitic lime, magnesium oxide, and magnesium sulfate and yield response was measured (Table 2). The results indicate that the highest yielding treatments and lowest yielding treatments both occurred with Ca:Mg ratios that spanned the same ranges, thus indicating the Ca:Mg ratio was not the reason for measured yield differences. Conclusions from the researchers were "The results strongly suggest that for maximum crop yields, emphasis should be placed on providing sufficient, but nonexcesive levels of each basic cation rather than attempting to attain a favorable basic cation saturation ratio (BCSR), which evidently does not exist." Various greenhouse and field trials indicate that crop productivity is not influenced by ranges from less than 1:1 to more than 25:1--ratios outside of what is normally measured in soils. Plants also play a role in Ca and Mg uptake and exclude excess Ca or Mg at the root surface.

Also, application of Mg does not imply there will be soil physical or crop production problems; that is, Mg application is not "bad" for soils. For example, in a study conducted by Webb, potash and potassium-magnesium sulfate (K-Mag) were applied annually to a Webster soil (total of 784 lb Mg/acre over an 8-year period). The yields in Table 3 indicate a response to applied potassium, but no effect of applied Mg.

In summary, the Ca:Mg ratio concept is unproven and should not be used as a basis for fertilization or liming practices. Having sufficient levels of Ca and Mg is the proper method of evaluation, rather than trying to manipulate ratios. We are fortunate in Iowa that soil Ca and Mg levels are normally adequate, and maintenance of plant-available Ca and Mg occurs either because the soil has a large supply or because of liming with local quarry limestone to maintain adequate soil pH for crop production.

More information on Ca:Mg ratios can be found in North Central Regional Extension publication Soil Cation Ratios for Crop Production," which is available from your extension office or at Web site http://www.extension.umn.edu/distribution/cropsystems/DC6437.html.

Table 1. Exchangeable Ca, Mg, and Ca:Mg ratio of several Iowa soils.

Soil	CEC	Ca	Mg	Ca:Mg Ratio
	meq/100 g			
Kenyon	14.0	8.5	2.6	3.3
Readlyn	19.5	14.5	4.2	3.5
Klinger	26.2	20.0	5.2	3.8
Dinsdale	20.5	14.6	4.2	3.5
Tama	20.6	13.9	3.4	4.1
Muscatine	28.3	20.4	7.1	2.9
Primghar	32.7	22.4	7.4	3.0
Sac	29.8	20.6	5.5	3.7
Marcus	43.9	37.5	11.9	3.2
Ida	22.4	16.9	5.3	3.2
Monona	22.4	18	6.2	2.9
Napier	27.6	23.5	3.2	7.3

CEC, cation exchange capacity.

Table 2. Ranges in Ca:Mg for the five highest and five lowest yield levels for six crop-years and 12 treatments.

Yield Level	Corn 1975	Corn 1976	Soybean 1977	Wheat 1978	Alfalfa 1979	Alfalfa 1980
Highest five	5.7-26.8	5.7-14.2	5.7-14.9	5.7-14.0	5.7-26.8	6.8-26.8
Lowest five	5.8-21.5	5.0-16.1	2.3-16.1	6.8-21.5	8.2-21.5	5.7-21.5

Adapted from: McLean, E.O., R.C. Hartwig, D.J. Eckert, and G.B. Triplett. 1983. Basic cation saturation ratios as a basis for fertilizing and liming agronomic crops. II. Field studies. Agronomy Journal 75: 635-639.

Table 3. Effect of broadcast potash and potassium-magnesium sulfate (K-Mag) applied to a Webster soil on corn yield.

Year	Control	Potash	K-Mag
	bu/acre		
1967	146	160	161
1968	148	161	160
1969	144	139	144
1970	108	130	124
1971	147	157	160
1972	129	150	152
1973	115	129	129
1974	120	133	130
8-yr mean	132	145	145

Potassium applied at 160 lb K/acre annually. K-Mag supplied 199 lb S/acre and 98 lb Mg/acre annually.

Source: Webb, J. 1978. The sulfur situation in Iowa. Proceeding of the 30th Annual Fertilizer and Ag Chemical Dealers Conference. Jan 10-11, Des Moines, IA. Extension Publication EC-1270q. Iowa State University, Ames.

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