Sunland Analytical
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Effect of Soil Ca:Mg Ratio on Crop Yield

Growth of the theory.

Beginning in the 1890's, it was suggested that a specific ratio of soil Calcium (Ca) to Magnesium (Mg) might be beneficial to plant growth and/or crop quality and production. This supposition seems most reasonable. After all, if plants internally maintain an approximate ratio between these two elements, it might be easier for the plant to thrive if the soil presented these elements in a ratio that would approximate the plant Ca:Mg ratio. Given this condition, it would seem equally reasonable that the lessor amount of energy that the plant utilized to control the proportion of Calcium and Magnesium could be utilized to improve plant growth and/or crop quality and production.

The theory that there was an ideal soil Calcium to Magnesium ratio was advocated by Albrecht et al. and Bear et al. in the late 1930s and '40s. They suggested that a ratio of 65:10, Calcium:Magnesium was optimal in the soils studied in Missouri and New Jersey. Additionally, Albrecht utilized some unique alternate techniques to evaluate the effects of added Calcium on plant quality. This included feeding lespedeza hay, grown in fields with varying amounts of lime, to rabbits. After six weeks, the rabbits were sacrificed and the characteristics of their femur bones evaluated. The bones were heavier, longer, and wider than in control animals. Interesting; but a significant stretch to equate the effects seen with adding lime to a field. Other more conventional approaches indicate that increasing soil Ca resulted in increasing nodulization in alfalfa. While this study has been criticized for lack of pH control, it's face value supported the reasonably accepted concept about the Ca:Mg ratio.

Does current data support the theory?

Given the common sense approach that this theory "seems reasonable", many others have set out to establish the optimal Ca:Mg ratio. These studies were under taken, not questioning the theory's validity, but simply to optimize growing conditions. However, in test after test, there is no observable effects on crop yield when the Ca:Mg ratio was modified, over very wide ranges.

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A recent study by Schonbeck (Report to Organic Farming Research Foundation, 2000), had the goal "to validate the Albrecht formula in organic production". Five sites were utilized in the South Eastern U.S. for evaluating, among other things, marketable yield. He found no difference in marketable yields in low and high Calcium (utilized to modify the Ca:Mg ratio) treatments. These results led Schonbeck to conclude: "Findings to date have led to a shift in focus toward developing a holistic, site-specific and resource-conserving approach to soil nutrient balance."

In another group of experiments, McLean et al. (Soil Sci.Soc 36: 927 [1972]; Agro.J 75: 625 [1983]) also set out to establish the optimal Ca:Mg ratio. Having been Albrecht's student, this approach would be reasonable. His extensive study included corn, soybean, wheat and alfalfa; each grown in soils with varying Ca:Mg ratios. The Ca:Mg ratios ranged from about 2.5 to slightly more than 25. His conclusion was: "for maximum crop yield, emphasis should be placed on providing sufficient, but not excessive levels of each basic cation rather than attempting to attain a favorable basic cation saturation ratio which evidently does not exist."

Other studies indicate the lack of effects of changing Ca:Mg ratios on alfalfa yield (Hunter, 67: 53[1949]; McLean & Carbonell, Soil Sci.Proc 36: 927 [1972]). Likewise, Rehm (Univ. Extension DC6437 [1994]) at the University of Minnesota demonstrated with alfalfa and corn that modification of the CA:Mg ratio had no effect on yield as long as there was adequate amounts of nutrients in the soil. Liebhardt, at the University of California-Davis and involved with these studies in several locations, provided the following synopsis of his work (sare.org /sanet_mg/archives [1998]). He summarized an eleven year study on corn an soybeans which indicated that "you do not need specific ratios of Ca:Mg to maximize yield."

Many other short reports of field trials indicate the apparent lack of response to modification of the Ca:Mg ratio exist in extension service reports. Though significant effort was made; no scientifically designed, statistically validated data purporting increased yields due to modification of the Ca:Mg ratio was found. Such data would be welcomed if available.

Are there other considerations ?

When modifying the Ca:Mg ratio utilizing lime applications, effects on the soil pH must be evaluated. Agricultural lime (Calcium Carbonate) has a pH of 8.5 and it is typically applied to soil to elevate the soil pH. However, much of the soil in the

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Western States have adequately high pH values and adding lime to modify the Ca:Mg ratio may elevate the soil pH to levels that are not optimal for the specific crop being grown. Additionally, as the pH increases above 7 nutrients including, phosphate, iron, manganese and zinc are altered in the soil and become less available for plant uptake and potentially decrease yield.

If the theory is acceptable, what would be required to make soil modifications and is there an reasonable return on investment?

The proposed ratio of 65:10 (Ca:Mg) is significantly different than what exists in the Western States served by Sunland Analytical. Upon review of recent soil samples analyzed by Sunland, which included samples from California, Arizona, Nevada and Oregon, the average Ca:Mg ratio for 25,000 samples was 3.35 or 33.5:10. Of course the analytical values, from samples taken in four states, varied significantly; but the average Calcium and Magnesium values were 2085 ppm and 622 ppm, respectively. The calculations for the amount of amendments that would be necessary to modify the top 6 inches of soil to a Ca:Mg ratio of 65:10 provides a value in excess of 6 tons lime per acre or 9 tons of gypsum per acre. Further, to maintain this ratio, there would be significant annual applications required to maintain the Calcium as the constituents in the top 6 inches of soil equilibrates with the underlying soil. If there were a reasonable guarantee of increased yield, a justification for this expense and effort could be made.

The "bottom line" is the grower's bottom line. These studies suggest that recommendations for soil amendment and fertilization fit the requirements of the crop and the historic yield capacity of the field. Search for significant improvements in yield are certainly a goal of all in our industry, but even though attractive conceptually, the "ideal" Calcium to Magnesium ratio doesn't appear to exist and such modification attempts don't appear to increase yields.