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# Plant-Available Calcium, Magnesium and Sulfur Levels in Soils Used for Corn Production in Michigan

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## INTRODUCTION

Deficiencies of the secondary plant nutrients calcium, magnesium and sulfur are not common in Michigan. Recent summaries of levels in surface soil suggest that average calcium levels are decreasing while magnesium levels are not changing greatly (4).

The Michigan State University Soil Testing Laboratory does not routinely test for sulfur. Therefore, little is known about trends with this essential element. However, it is assumed that levels are gradually decreasing because much less sulfur is now added to soil (6).

This report is part of an inventory on the current status of plant-available nutrients in soils used for corn production in Michigan. Averages and ranges in soil pH, plant-available phosphorus and exchangeable potassium levels have been reported (7).

The purpose of this investigation was to evaluate the calcium, magnesium and sulfate-sulfur status of soils used for corn production. Because corn is grown so extensively, it was assumed that the test levels reflect the nutrient status of most soils in southern Michigan.

## RESEARCH METHODS

Soil profile samples were collected in September and October of 1974 with the cooperation of a professional soil classifier on the basis of kinds of soil where corn is intensively grown. The soil management group (SMG) concept (5) was used to determine where and how many profiles should be sampled. No less than two profiles represented any single SMG or county. All counties south of the Oceana-Bay tier were included in this study.

Generally, three samples were taken of each profile. Sample "A" represented the Ap (plow layer) horizon. In most profiles, sample "B" represented the B horizon. However, for soils with thick B horizons this sample represented the upper portion of the B horizon. Sample "C" usually represented the parent material of the soil, but in some profiles represented the lowest part of the B horizon that could be reached with a 5-ft bucket auger, or the lower horizon of a soil with two-storied parent material. Details on profile locations, sample methods and preparation for laboratory analysis were outlined in an earlier publication (7).

Exchangeable calcium and magnesium determinations were made on each profile sample by extracting with neutral normal ammonium acetate (1:8 soil-to-extractant ratio, shaken for 5 min).

Only the surface soil was analyzed for sulfate-sulfur because plant-available sulfur forms are closely associated with the organic fractions of surface soil (2). In humid regions like Michigan, soils generally have only small quantities of the mineral forms of sulfur as a source of this nutrient (2, 6). Sulfate-sulfur levels were evaluated in the soils laboratory of the University of Wisconsin. The soil was extracted with 2 N acetic acid which contained 500 ppm P as calcium phosphate. The soil-to-extractant ratio was 1:5.

## RESULTS AND DISCUSSION

Each of the three elements is considered separately in this discussion. The data are grouped in agreement with the SMG concept. Mean levels are shown in parentheses in Tables 1, 2 and 3.

### Exchangeable Calcium

The ranges and mean levels of exchangeable calcium are reported in Table 1. As expected, soil test levels varied considerably and covered a wide range even within a single SMG. Regardless of this, strong trends were shown by the means.

The surface horizons of the well drained "a" soils all had lower mean levels of exchangeable calcium than those of the somewhat poorly drained "b" soils, which were lower than those of the poorly drained "c" soils. This occurred without exception for each textural group. This trend was also common in the subsoil (B samples) and the parent material (C samples) of the sandy loam and coarser soils and two-storied soils.

As expected, the fine-textured soils (excluding organic soils) had the highest mean levels of exchangeable calcium. This was generally true for the three profile samples, A, B and C.

**Table 1. Exchangeable calcium levels, ranges and means (in parentheses) in the soil management groups sampled**

| Dominant profile texture | Soil mgt. group symbol | Profile sample symbol | 100 lb/acre Natural drainage class[a] a | b | c |
|---|---|---|---|---|---|
| Clay, 40-60% | 1 | A | 31-43(37) | 33-54(45) | 74-87(80) |
| | | B | 27-62(44) | 19-57(43) | 59-77(71) |
| | | C | 81-94(88) | 72-96(83) | 47-93(75) |
| Clay loam | 1.5 | A | 23-48(32) | 30-61(44) | 44-88(64) |
| | | B | 23-62(43) | 32-54(42) | 33-65(47) |
| | | C | 22-96(74) | 69-81(75) | 38-83(68) |
| Loam | 2.5 | A | 9-53(27) | 18-70(43) | 31-76(54) |
| | | B | 14-45(28) | 30-57(38) | 29-59(42) |
| | | C | 9-81(55) | 28-83(62) | 28-84(56) |
| Sandy loam | 3 | A | 9-55(22) | 28-68(44) | 77-96(89) |
| | | B | 9-59(22) | 28-47(36) | 24-48(35) |
| | | C | 3-52(19) | 4-62(28) | 42-59(48) |
| Loamy sand | 4 | A | 6-34(15) | 4-86(39) | 14-85(45) |
| | | B | 4-25(10) | 3-49(18) | 14-48(26) |
| | | C | 1-43(13) | 10-51(33) | 2-24(14) |
| Sand | 5 | A | 8-14(10) | 6-48(27) | 30-91(53) |
| | | B | 4-11(7) | 1-32(12) | 4-11(7) |
| | | C | 2-11(5) | 1-35(13) | 2-37(19) |
| Sandy loam, 20-40 in., over loam | 3/2 | A | — | 34-44(39) | — |
| | | B | — | 23-25(24) | — |
| | | C | — | 64-70(67) | — |
| Loamy sand, 20-40 in., over clay to loam | 4/1, 4/2 | A | 18-23(21) | 17-38(31) | — |
| | | B | 2-28(15) | 13-33(21) | — |
| | | C | 34-56(45) | 34-87(65) | — |
| Sand, 40-60 in., over loam to clay loam | 5/2 | A | 15-18(17) | — | — |
| | | B | 1-6(3) | — | — |
| | | C | 1-23(12) | — | — |
| Muck | M, M/m, M/3, M/4 | A | — | — | 77-156(125) |
| | | B | — | — | 62-134(105) |
| | | C | — | — | 44-171(99) |

[a]Drainage class: a—well drained, b—somewhat poorly drained, c—poorly drained.

The highest levels of exchangeable calcium were found in the parent materials (C samples) of the fine-textured soils. Within a natural drainage class, the mean exchangeable levels of calcium decreased with increasing coarseness of the profiles. This was expected because of the initial calcareous nature of the parent materials of most of the soils included in this investigation and the increased leaching in the coarse-textured soils. The lowest individual test levels for calcium were obtained on the subsoils of the loamy sand and sand soils.

Calcium deficiencies in corn rarely occur in Michigan. Since less than 50 lb/acre of calcium is utilized in the production of a 100-bu crop (1), the test levels reported in Table 1 obviously are in a high range.

Because of the relatively high test levels of available calcium in all soils, the significance of a test for this nutrient is not immediately obvious. Calcium plays an indirect role in corn production by reducing soil acidity, enhancing root growth, increasing microbial activity and facilitating the uptake of several other essential plant food elements. Thus, the high calcium levels in Michigan soils help increase grain and silage yields.

Routine evaluation of calcium in a soil testing program is needed because the level of exchangeable calcium is used to determine the need for fertilizer magnesium.

Fertilizer recommendations for magnesium are currently made when "as a percent of the total bases (calcium plus magnesium plus potassium, expressed as milliequivalents per 100 g of soil), potassium levels exceed magnesium" or when soil magnesium, as a percent of total bases, is less than 3% (3). Such calculations are now included on the soil test report form and serve as a basis for magnesium recommendations.

No close relationship existed between calcium levels reported here and pH levels published previously (7).

**Table 2. Exchangeable magnesium levels, ranges and means (in parentheses) in the profiles of soil management groups sampled**

| Dominant profile texture | Soil mgt. group symbol | Profile sample symbol | 100 lb/acre Natural drainage class[a] a | b | c |
|---|---|---|---|---|---|
| Clay, 40-60% | 1 | A | 4-6(5) | 6-9(8) | 9-15(12) |
| | | B | 4-17(9) | 9-22(17) | 9-16(12) |
| | | C | 5-7(6) | 10-22(18) | 5-12(9) |
| Clay loam | 1.5 | A | 3-9(5) | 5-13(8) | 5-11(8) |
| | | B | 6-15(9) | 4-25(15) | 6-11(9) |
| | | C | 4-13(7) | 5-22(14) | 5-11(10) |
| Loam | 2.5 | A | 0.7-7(4) | 2-8(5) | 3-12(7) |
| | | B | 2-8(5) | 5-9(7) | 4-12(7) |
| | | C | 0.7-9(5) | 2-10(5) | 4-8(6) |
| Sandy loam | 3 | A | 0.4-9(2) | 3-6(4) | 9-14(11) |
| | | B | 0.3-6(3) | 3-7(5) | 2-8(6) |
| | | C | 0.1-4(2) | 0.1-3(2) | 1-3(2) |
| Loamy sand | 4 | A | 0.3-2(1) | 0.7-9(4) | 0.8-5(3) |
| | | B | 0.1-3(1) | 0.2-4(2) | 1-2(1) |
| | | C | 0.1-4(1) | 0.6-2(1) | 0.1-2(1) |
| Sand | 5 | A | 0.1-0.7(0.3) | 0.6-6(2) | 2-10(4) |
| | | B | 0.1-0.3(0.2) | 0.2-1(0.5) | 0.2-1(0.6) |
| | | C | 0.1-0.3(0.2) | 0.2-0.9(0.5) | 0.4-3(2) |
| Sandy loam, 20-40 in., over loam | 3/2 | A | — | 2-5(4) | — |
| | | B | — | 4-4(4) | — |
| | | C | — | 3-3(3) | — |
| Loamy sand, 20-40 in., over clay to loam | 4/1, 4/2 | A | 2-3(2) | 0.8-2(2) | — |
| | | B | 0.3-5(3) | 0.5-3(2) | — |
| | | C | 4-5(4) | 3-9(6) | — |
| Sand, 40-60 in., over loam to clay loam | 5/2 | A | 0.7-2(1) | — | — |
| | | B | 0.1-0.9(0.5) | — | — |
| | | C | 0.3-5(3) | — | — |
| Muck | M, M/m, M/3, M/4 | A | — | — | 5-16(10) |
| | | B | — | — | 4-11(8) |
| | | C | — | — | 1-8(6) |

[a]Drainage class: a—well drained, b—somewhat poorly drained, c—poorly drained.

The explanation to this is related to the buffer capacities of the soils involved in these investigations. The organic soils represent this situation well—they had some of the highest tests for calcium and some of the lowest pH tests, as low as pH 5.5.

### Exchangeable Magnesium

In contrast with calcium, magnesium deficiencies in corn and other crops are occasionally identified in Michigan. This usually occurs where corn is grown on acid soils with a sand, loamy sand, or sandy loam plow layer over a coarse-textured or gravelly subsoil such as those in SMG 3, 4 and 5.

An explanation of the location in the state where magnesium deficiency occurs becomes evident when considering the low soil test levels for magnesium that occur even in the subsoils of soils in these SMG (Table 2).

In Michigan, any level below 75 lb/acre is presently considered to represent a low level of this element and a situation where the use of magnesium-containing fertilizer or lime is likely to increase both corn grain and silage yields.

Magnesium deficiencies are less likely to develop on clay and clay loam soils (SMG 1 and 1.5). In these groups, all samples, regardless of depth, had at least 300 lb/acre of magnesium. On the average, the loam soils (SMG 2.5) tested well above the threshold value of 75 lb/acre of available magnesium.

The well drained sandy loam soils (3a) had mean levels above the threshold value, but several samples tested well below 75 lb/acre. Both the SMG 4a and 4b (loamy sands) soils contained samples with low exchangeable magnesium levels. This was also the situation with SMG 5a and 5b soils, as well as the coarser-textured two-storied soils (SMG 4/1, 4/2 and 5/2).

The available magnesium levels found in the organic soils suggest that there is little opportunity for magnesium deficiences to occur on these soils. Surface horizons averaged approximately one-half ton of magnesium per acre. This is ample magnesium, since a 100-bu corn crop frequently utilizes less than 50 lb/acre (1).

In regard to drainage classes, the plow layer of the well drained "a" soils, without exception, contained lower average levels of magnesium than that of the somewhat poorly drained "b" soils. With two exceptions, the "b" soils had a lower mean magnesium level than the poorly drained "c" soils.

There were no clearly identified trends in mean magnesium levels as related to depths in the profile, except in organic and sandy loam and coarser soils. There the mean magnesium levels tended to be higher in the plow layer and to decrease in the deeper horizons.

### Sulfate-Sulfur

Sulfate is an end product of decomposition reactions and the form in which sulfur is used by plants. Several soil testing laboratories now have methods for evaluating sulfate-sulfur levels.

The University of Wisconsin has correlated sulfur-deficient soils in its state with the sulfate-sulfur test. The threshold value currently used in Wisconsin is 15 lb/acre. Levels below this are considered in the low range. As seen in Table 3, many samples tested well below this value, particularly the well drained and somewhat poorly drained loamy sand (SMG 4a

**Table 3. Sulfate-sulfur, range and average (in parentheses) in the plow layer of the soil management groups sampled**

| Dominant profile texture | Soil mgt. group symbol | lb/acre Natural drainage class[a] a | b | c | Mean |
|---|---|---|---|---|---|
| Clay, 40-60% | 1 | 13-38(28) | 24-42(35) | 12-27(21) | 25 |
| Clay loam | 1.5 | 0-26(18) | 7-41(29) | 17-33(24) | 24 |
| Loam | 2.5 | 0-30(15) | 0-54(17) | 0-45(19) | 17 |
| Sandy loam | 3 | 0-42(17) | 17-31(23) | 27-86(58) | 23 |
| Loamy sand | 4 | 0-26(11) | 0-31(16) | 3-30(19) | 14 |
| Sand | 5 | 4-23(10) | 0-15(9) | 1-218(63) | 27 |
| Sandy loam, 20-40 in., over loam | 3/2 | — | 23-38(31) | — | 31 |
| Loamy sand, 20-40 in., over clay to loam | 4/1, 4/2 | 10-22(16) | 6-21(14) | — | 15 |
| Sand, 40-60 in., over loam to clay loam | 5/2 | 19-27(23) | — | — | 23 |
| Muck | M, M/m, M/3, M/4 | — | — | 42-176(113) | 113 |
| | Range | 0-42 | 0-54 | 0-218 | |
| | Mean | 16 | 19 | 41 | |

[a]Drainage class: a—well drained, b—somewhat poorly drained, c—poorly drained.

and 4b) and sand soils (SMG 5a and 5b). This is in agreement with previous investigations (6).

In drawing conclusions from these data, it should be recognized that the samples were collected in the late summer when the sulfate contents would be at the lowest level for the year.

The ranges in sulfate-sulfur were as wide as anticipated, but the levels of zero were not expected, especially in the loam (SMG 2.5) and clay loam (SMG 1.5) soils. The average levels of sulfate-sulfur tended to be higher in the naturally poorly drained "c" sandier groups which are naturally higher in organic matter. The organic soils were highest in sulfate-sulfur. The levels in the naturally better drained "a" and "b" soils tended to increase with increasing clay content. However, the sulfate-sulfur levels were low enough to suggest a need for concern when producing crops with high sulfur requirements.

Because variations in sulfate-sulfur levels were great and an explanation to this is not apparent, it is concluded that at least some of the variation was caused by the management methods used by individual farmers. No data on the use of sulfur-containing materials such as gypsum or livestock manure are available. Available sulfur levels in some soils were low enough that research involving high sulfur requiring crops is needed.

## SUMMARY AND CONCLUSIONS

Soil profile samples from 135 locations in southern Michigan were collected in September and October of 1974 and tested for exchangeable calcium and magnesium and sulfate-sulfur. Mean levels and ranges are reported on the basis of soil management groups.

Exchangeable calcium levels ranged between 126 and 17,110 lb/acre. The highest levels of calcium occurred in the organic soils. In the plow layer of the mineral soils, the highest average levels were found in the fine-textured SMG 1 and 1.5 soils. In general, the parent materials contained the most exchangeable calcium.

Magnesium levels ranged between 10 and 2,537 lb/acre. The organic and fine-textured soils contained the highest levels of magnesium, while many of the more sandy soils had test levels that are considered deficient.

Only the plow layers were evaluated for sulfate-sulfur. Sulfate levels in some instances were unexpectedly low, ranging down to undetectable amounts. The organic soils were highest and the poorly drained sandy soils averaged higher in sulfate-sulfur than the better drained sandy soils.

The results reported emphasize the need to regularly and systematically test soils so that high and balanced fertility levels can be maintained. Also, the data suggest a need for a research program on the desirability of using sulfur-containing fertilizers.

## REFERENCES

1. Benne, E. J.; E. Linden, J. D. Grier and K. Spike (1964). Composition of corn plants at different stages of growth and per-acre accumulations of essential nutrients. Mich. Agr. Expt. Quar. Bul. 47:69-85.
2. Chesnin, Leon (1972). Calcium, magnesium, sulfur, and micro-nutrients, Chapter IV, The Fertilizer Hand Book, The Fertilizer Institute.
3. Christenson, D. R.; R. E. Lucas and E. C. Doll (1972). Fertilizer recommendations for Michigan vegetables and field crops. Mich. State Univ. Ext. Bul. E-550.
4. Doll, E. C.; J. C. Shickluna and J. F. Demeterio (1972). Levels and changes in soil test levels in Lower Michigan 1962-1971. Mich. Agr. Expt. Sta. Res. Rpt. 197.
5. Mokma, D. L.; E. P. Whiteside and I. F. Schneider (1974). Soil management units and land use planning. Mich. Agr. Expt. Sta. Res. Rpt. 254.
6. Robertson, L. S. and M. L. Vitosh (1974). Recent field research on cash crop yields as affected by supplemental sulfur. Mich. Agr. Expt. Sta. Res. Rpt. 265.
7. Robertson, L. S.; D. L. Mokma and D. D. Warncke (1975). Test levels in soil profiles of Michigan corn fields. Mich. Agr. Expt. Sta. Res. Rpt. 281.

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