Essential Secondary Elements: Calcium

Michigan State University
Cooperative Extension Service
L.S. Robertson, D.R. Christenson, and D.D. Warncke
Extension Specialist in Crop and Soil Sciences

August 1976
4 pages

MSU AG FACTS
COOPERATIVE EXTENSION SERVICE

No. 103 Extension Bulletin E-996 August 1976

Essential Secondary Elements:

CALCIUM

By L. S. Robertson, D. R. Christenson, and D. D. Warncke
Extension Specialists in Crop and Soil Sciences

PLANTS AND ANIMALS do not grow normally without ample calcium (Ca). While Ca deficiencies sometimes occur in animals, they seldom exist in crops.

Calcium, in addition to magnesium (Mg) 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.

Calcium in Animals

Calcium is a component of every animal cell. It is concentrated in bones and teeth. Milk contains relatively high levels.

Calcium deficiencies in a diet can cause rickets in children, thin or defective egg shells and brittle bones. Feed stuff high in Ca reduces opportunities for deficiencies.

Calcium in Plants

Calcium is also a part of every plant cell. It is essential for cell division and contributes to cell wall strength. The Ca content of different crops varies considerably, as reported in Table 1. Legumes use more Ca than other classes of crops. Seeds generally contain relatively low levels. Thus, some time is required to significantly reduce soil Ca levels when only grain is harvested.

Table 1. The Calcium Content of Field Crops.[1]

Crop	Plant part	Yield	Calcium lbs. per acre
Alfalfa	Hay	4 T	112
Barley	Grain	80 Bu	2
	Straw	2 T	14
Corn	Grain	150 Bu	2
	Stover	4.5 T	26
Navy beans	Seed	40 Bu	7
Oats	Grain	80 Bu	2
	Straw	2 T	8
Soybeans	Seed	40 Bu	7
Sugar beets	Roots	20 T	43
Wheat	Grain	60 Bu	2
	Straw	2 T	9

[1] *Calculated from several sources.*

Most field crops do not show deficiency symptoms for Ca if the soil pH is adequate, other essential elements are within a normal range, and if soil moisture levels are not limiting growth. Under other conditions, symptoms are sometimes observed on both fruit and vegetable crops.

Calcium is a relatively immobile element within a plant. It does not easily redistribute in a plant subject to stress from shortages. It does not move from old leaves to new. Hence a continuous supply of Ca is essential. Also, seed contains too little Ca to supply the plant beyond emergence.

An acute deficiency impairs root growth, and rotting may occur. Aerial parts may also be affected. Black heart in celery, tipburn in lettuce and cabbage, blossom end rot in peppers and tomatoes, carrot cavity, and bitter pith or cork spot in apples are examples of symptoms that have been seen in Michigan. Symtoms on many crops are well described in the literature as a product of greenhouse research and investigations using nutrient solutions.

Calcium uptake by plants is affected by many conditions in addition to the amount in soil. Ammonium ions (NH_4^+) in the root zone tend to limit uptake as well as transport within a plant. Similar effects have been observed with high levels of potassium (K) and sodium (Na).

Chemical analysis of plant tissue provides a clue on the nutrient status of a crop. The percent Ca values in Table 2 represent the "sufficiency range," which is a level essential for high yields. Levels below those reported imply the possibility of production problems, while those above reflect excessive levels and the possibility of other nutrient deficiencies.

The information in Table 2 can be used most easily when samples are collected at the indicated time. Interpretation of specific data is more difficult when

Table 2. Calcium Sufficiency Ranges for Several Crops.[1]

Crop	Plant part and time of sample	Percent
Corn	Ear leaf at early silking time	0.21 - 1.00
Soybeans ..	Top mature leaf before flowering	0.36 - 2.00
Alfalfa	Aerial part — 6 inches to flowering	1.76 - 3.00
Wheat	Upper leaves before first bloom	0.21 - 1.00
Sugar beets	Center fully developed leaf, mid-season	0.36 - 1.20
Vegetables	Top fully developed leaves, mid-season	0.35 - 2.00
Potatoes	Petioles of recently mature leaves, mid-season	0.36 - 0.50

[1] *From MSU Extension Bulletin 486.*

Table 3. Average Exchangeable Calcium Levels of Soil Profiles in Southern Michigan.[1]

Dominant profile texture	Texture symbol	Profile sample symbol[2]	Natural drainage class: Well a	Somewhat poorly b	Poorly c
			Pounds/acre[3]		
Clay and Clay Loam	1 & 1.5	A	3,450	4,450	7,200
		B	4,350	4,250	5,900
		C	8,100	7,900	7,650
Loam and Sandy Loam	2.5 & 3	A	2,450	4,350	7,150
		B	2,500	3,700	3.850
		C	3,700	4,500	5,200
Loamy Sand and Sand	4 & 5	A	1,250	3,300	4,900
		B	850	1,500	1,650
		C	900	2,300	1,650

[1] *For more details — see MSU Agr. Exp. Sta. Res. Rpt. 286.*
[2] *A — plow layer; B — subsoil; C — parent material.*
[3] *Equivalent to 2 million pounds of soil material.*

other plant parts are involved or when samples are obtained at other than the indicated time. Soil tests aid in interpreting plant tissue analysis.

In summary, chemical analyses of plant tissue for Ca as an aid in interpreting plant growth problems is frequently of limited value. When high or low extremes are encountered, investigate the level of other nutrients, especially potassium (K) and magnesium (Mg).

Calcium in Soil

Calcium occurs as a part of both primary and secondary 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 soil colloids, the Ca is referred to as "exchangeable."

Most exchangeable Ca is in a form that is available to plants, while the Ca in primary and secondary minerals is only very slowly available. Because of this, analysis for total Ca is not closely related to plant growth.

Quantities of exchangeable Ca vary greatly between kinds of soil and also within the soil profile, as is shown in Table 3. The naturally poorly drained soils contain the most exchangeable Ca. Fine-textured soils have significantly more Ca than sandy soils. Except for the loamy sands and sand soils, the surface horizons contain less exchangeable Ca than the subsoils.

If exchangeable Ca is available to crops, it is evident that most soils in Michigan contain sufficient Ca and that deficiencies are not likely to occur. (Compare data in Tables 3 and 1.) This serves as a basis for the fact that the M.S.U. soil testing laboratory does not use threshold values for Ca. The actual Ca level in soil is not important as long as the pH level is within an adequate range. Thus, there is no reason to recommend Ca-containing fertilizer on the basis of low Ca test levels.

Routine evaluations for soil Ca, however, are useful in another way. The M.S.U. laboratory uses Ca tests to help determine the need for fertilizer magnesium (Mg). Fertilizer recommendations for Mg are made when "as a percent of the total bases (*Ca* + Mg + K, expressed as milliequivalents per 100 g of soil), K levels exceed Mg" or when soil Mg, as a percent of total bases, is less than 3 percent. Such calculations are reported on the M.S.U. soil test report form.

Calcium in Water

Rain and snow water contain very little or no Ca. However, when water percolates through soil material or flows over the soil surface, the more soluble compounds enter into solution. Calcium levels in well water are extremely variable but generally are present in larger quantities than in surface waters. The quantity in well water may be sufficient to increase soil pH levels if ample irrigation water is used.

Typical Ca levels in selected Michigan streams are shown in Table 4. The use of 12 inches of irrigation water from such sources does not supply enough Ca to affect soil pH levels. The quantity, however, is sufficient to meet the annual requirements of most crops.

[1] *Ion — an electrically charged form of the element.*
[2] *Colloid — matter having a very small (submicroscopic) particle size and a correspondingly high surface area per unit of mass.*

Table 4. Calcium Levels in Selected Michigan Rivers.[1]

River	County	Calcium	
		ppm	Pounds/ acre foot
Sturgeon	Houghton	16	43
Escanaba	Delta	27	73
Pine	Charlevoix	36	97
Elk	Antrim	42	113
Cheboygan	Cheboygan	44	119
Thunderbay	Alpena	50	135
Flint	Saginaw	74	200
Cass	Saginaw	88	238
Rouge	Wayne	52	140
Raisin	Monroe	89	240
St. Joseph	Berrien	66	178
Grand	Ottawa	63	170
Muskegon	Muskegon	44	119

[1] *Data from Michigan Deyartment of Natural Resources, Bureau of Water Management.*

Table 5. Average Calcium Levels in Livestock Manure.[1]

Kind of manure	Rate of manure (tons/acre)		
	1	5	20
	Calcium applied (pounds/acre)		
Chicken — no litter	58	290	1160
Chicken — floor litter	28	140	560
Dairy cows	6	30	120
Fattening cows	2	10	40
Hog	11	55	220
Horse	16	80	320
Sheep	12	60	240

[1] *Data calculated from several sources.*

Calcium in Manure

The Ca content of livestock manure is derived entirely from feed consumed by the animal and from bedding if used. The data in Table 5 illustrate that the use of more than 5 tons per acre should supply ample Ca for high crop yields.

Calcium in Municipal Sludges and Waste Water Effluents

Recent anlysis of 40 samples of sludge from several municipalities in Michigan showed that Ca levels varied greatly, ranging between 1.4 and 25.2 percent, which is equivalent to 27 and 504 pounds per dry ton.

Waste water effluents from 58 Michigan municipalities ranged between 28.7 and 187 ppm Ca, which is equivalent to 78 and 509 pounds per acre foot.

Table 6. Calcium Contents of Lime, Fertilizer and Soil Amendment Materials.[1]

	Chemical formula	Percent Ca
Lime materials		
Blast furnace slag	$CaSiO_3$	29
Calcitic limestone	$CaCO_3$	31
Dolomitic limestone	$CaCO_3 + MgCO_3$	21
Hydrated lime	$Ca(OH)_2$	46
Marl	$CaCO_3$	24
Precipitated lime	CaO	60
Fertilizer materials		
Calcium nitrate	$Ca(NO_3)_2$	19
Rock phosphate	$3\ Ca_3(PO_4)_2 \cdot CaF_2$	33
Normal super phosphate	$Ca(H_2PO_4)_2$	20
Triple super phosphate	$Ca(H_2PO_4)_2$	13
Reax calcium	CaMPP	4–12
THIS calcium	CaMPP	6
Soil amendments		
Gypsum	$CaSO_4 \cdot 2\ H_2O$	22

[1] *From the Fertilizer Handbook — The Fertilizer Institute.*

Thus, waste water effluent and municipal sludges represent good sources of Ca.

Calcium in Lime, Fertilizer and Soil Amendments

Lime, fertilizer and certain soil amendments represent the most important sources of Ca used in crop production. Typical levels of Ca in such materials are shown in Table 6. Recently, organic complex sources of Ca became available but are not now extensively used. The most successful use of such materials has been on acid soil where it was not practical to lime.

Recommendations for Calcium

Calcium is only infrequently recommended in Michigan because, with a high management level, deficiencies are unlikely. A sound soil testing program is urged to serve as a basis for maintaining an adequate pH level as well as a reasonable balance of nutrients.

Where deficiencies exist on high-value vegetable or fruit crops, foliar sprays are effective. It is important to cover terminal growth, new leaves and fruit completely with the Ca spray because application to older leaves will not greatly benefit the plant.

Weekly sprays of calcium chloride ($CaCl_2$) at 5 to 8 pounds per acre or calcium nitrate at 10 to 15 pounds are suggested if soil or climatic conditions cause deficiencies.

Summary

Calcium (Ca) is an essential element for both plants and animals. Deficiencies usually do not occur in Michigan. It is important, however, to maintain adequate quantities of Ca in soils so that nutritious feed can be produced. Because acid soils are relatively low in Ca, soils should be limed to increase pH levels and to improve Ca levels. The value of Ca in municipal sludges and waste water effluent is variable.

Foliar sprays containing Ca are suggested for high value vegetable crops growing on soils with high ammonium (NH_4^+), sodium (Na) or potassium (K) salt levels. Low soil moisture conditions increase chances for Ca disorders.

MICHIGAN REFERENCES ON CALCIUM

1. Christenson, D. R. (1975) Let's use lime on Michigan soils — 20 questions and answers. Info. Sheet, Dept. of Crop and Soil Sciences, MSU.
2. Christenson, D. R. and E. C. Doll (1973) Lime for Michigan soils. MSU Ext. Bul. 471.
3. Christenson, D. R., R. P. White, and E. C. Doll (1973 Yields and magnesium uptake by plants as affected by soil pH and calcium levels. Agron. Jour. 65:205-206.
4. Doll, E. C. and P. E. Rieke (1965) Response of alfalfa to lime and fertilizer in northern Michigan. Mich. Agr. Exp. Sta. Quart. Bul. 47:494-504.
5. Doll, E. C., J. C. Shickluna and J. F. Demeterio (1972) Levels and changes in soil tests in lower Michigan 1962-1971. Mich. Agr. Exp. Sta. Res. Rpt. 197.
6. Ellis, B. G. (1961) Lime recommendations and the magnesium situation in Michigan. Mich. Fert. Conf. Proc. MSU, Dec. 7-8.
7. Miner, G. S. (1964) Relation of surface area of liming materials to reaction rate. M.S. Thesis, MSU.
8. Parfitt, R. L. and B. G. Ellis (1966) Studies on Michigan agricultural limestone. Mich. Agr. Exp. Sta. Quart. Bul. 49:12-23.
9. Robertson, L. S., D. L. Mokma, and D. D. Warncke (1975) Plant-available calcium, magnesium, and sulfur levels in soils used for corn production in Michigan. Mich. Agr. Exp. Sta. Res. Rpt. 286.
10. Robertson, L. S., D. L. Mokma, and D. D. Warncke (1975) Test levels in soil profiles of Michigan Corn fields. Mich. Agr. Exp. Sta. Res. Rpt. 281.
11. Ross, G. J., K. Lawton, and B. G. Ellis (1964) Lime requirements related to physical and chemical properties of nine Michigan soils. Soil Sci. Soc. Am. Proc. 28:209-212.
12. Warncke, D. D. and E. C. Doll (1973) Organic soil test levels and changes in Michigan 1962-1972. Mich. Agr. Exp. Sta. Res. Rpt. 233.

Cooperative Extension Service Programs are open to all without regard to race, color, creed, or national origin. Issued in furtherance of cooperative extension work in agriculture and home economics, acts of May 8, and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Gordon E. Guyer, Director, Cooperative Extension Service, Michigan State University, E. Lansing, MI 48824. Price 10 cents. Single copy free to Michigan residents.

1P—10M—8:76—Ja