CONSERVATION AGRONOMY TECHNICAL NOTES

U. S. DEPARTMENT OF AGRICULTURE NEW MEXICO SOIL CONSERVATION SERVICE

NOTE NO. 26

May 23, 1973

RE: Plant Food Elements - Calcium, Magnesium and Sulfur - The Secondary Plant Nutrients

The attached Technical Note on Secondary Plant Food Nutrients, or Elements, is the fourth of a planned series to provide information on plant food elements which are most likely to be deficient in our soils.

If additional copies of this Technical Note are needed for individual references and use in field work, request them from the Plant Science Section.

Attachment

AO
WRTSC, Portland - 2
Adjoining States - 1

11-64 4-L-19461

SECONDARY ELEMENTS - ABUNDANT OR SCARCE?

Calcium (Ca), Magnesium (Mg), and Sulfur (S) are called Secondary Plant Food Elements or Nutrients because they are also required by growing plants in fairly large quantities. These can also be classed as essential plant food elements. They may be present in some soils in adequate amounts and in inadequate amounts in other soils.

A few years ago very little attention was given to the importance of secondary elements. It had been thought that most of our soils contained sufficient natural supplies of calcium, magnesium and sulfur. In addition, commercial fertilizers usually supplied considerable amounts of these elements as impurities and carriers of the primary elements.

Intensive cropping, greater emphasis on higher yield per acre and the aging and depletion of our soils have all been factors in causing the need for all essential elements to become more pronounced. The fertilizer industries development of more highly refined materials containing more nitrogen, phosphorus and potassium has reduced the supplies of some secondary and trace elements in fertilizers.

If a soil contains too much calcium or potassium in relation to magnesium, the plants may be unable to get enough magnesium and begin to suffer from magnesium starvation. It is not only important to have a readily available supply of magnesium in the soil but also to maintain the proper ratio of calcium and potassium to the available magnesium.

The New Jersey Experiment Station found that under their conditions magnesium deficiencies were most likely to occur in plants when the ratio of available potassium to available magnesium in the soil exceeded one to two.

A number of authorities agree that there should be four to six times as much available calcium as there is magnesium in the soil. This suitable ratio will vary under different soil conditions because it depends upon the amount of clay in the soil and the type of clay. When the ratio between calcium and magnesium becomes wider than ten to one, plants have had difficulty in obtaining sufficient magnesium for best growth.

Calcium is a major constituent of various limestones, shells, slags, phosphate rock, superphosphate and gypsum.

Magnesium could be considered as a companion to calcium since it is similar in many of its characteristics and usually occurs in nature along with calcium salts. It is found in dolomitic limestone, magnesium sulfate, sulfate of potash-magnesia, magnesium oxide and seed meals.

Magnesium is generally deficient in soils that have not been limed throughout coastal areas from Maine to Alabama. Since soils for growing potatoes, tobacco, and tree fruits are usually not limed, fertilizer for these crops in the Eastern Coastal Region often carry guaranteed amounts of this nutrient. Cotton in the Southeast and sugar beets in parts of Michigan have also responded to applications of magnesium.

Sources of sulfur for crop use are natural sulfur and sulfur obtained from fertilizer materials such as gypsum, ordinary superphosphate, ammonium sulfate and potasium sulfate. A substantial amount of sulfur is liberated into the atmosphere in the burning of coal. Some of this sulfur returns to the earth through rainfall.

SOME FUNCTIONS OF SECONDARY PLANT FOOD ELEMENTS

Calcium

1. Promotes early root formation and growth.

2. It forms a structural part of the walls of plant cells.

3. Improves general plant vigor and stiffness of straw.

4. It tends to neutralize any harmful acids that are formed, and by doing so controls the acid-base balance in plant juices.

5. The addition of calcium in acid soils reduces any toxic acidity and while doing this, benefits the activity of micro-organisms, indirectly increasing the availability of nitrogen and other elements.

   Since calcium stimulates the activity of soil organisms, it helps to hasten the decomposition of organic matter and improve the physical condition of heavy soil. This increases the efficiency of manure and fertilizer applications.

6. It is thought to be of some help in the translocation of carbohydrates in the plant.

7. It is the active element in liming materials used to correct soil acidity and occurs in gypsum (calcium sulfate) which is used in treatment of saline and/or alkali soils.

8. Encourages grain and seed production.

9. Increases calcium content of food and feed crops.

Magnesium

1. It is a working companion of phosphorus and stimulates the assimilation of phosphorus by the plant.

2. Is essential in the formulation of chlorophyll, which gives the dark green color to leaves.

3. Helps to prevent chlorosis, a disease similar to anemia in animals.

4. It is thought to be essential for the formation of oils and fats.

5. It is necessary for the formation of sugar from carbon dioxide and water in sunlight.

6. It plays a part in the translocation of starch.

7. Helps to regulate the uptake of other plant foods.

Sulfur

1. Sulfur is utilized by the growing plant in the development of essential organic compounds, proteins, vitamins, etc.

2. It aids in the synthesis of oils.

3. It is a part of cystine, which is a constituent of protein.

4. Gives increased root growth.

5. It also helps to maintain the dark green color in plants.

6. Stimulates seed production.

7. Encourages more vigorous plant growth.

8. Promotes nodule formation on legumes.

SOME SYMPTOMS OF CALCIUM, MAGNESIUM, AND SULFUR STARVED PLANTS

Calcium

1. The growing point of the plant, the terminal bud, dies when there is a severe deficiency.

2. Margins of affected leaves have a scalloped appearance. These are usually the younger leaves. Foliage which is not affected this way is usually an abnormal dark green color.

3. The plant tends to shed its blossoms and buds prematurely.

4. The structure of the stem is weakened.

5. Young leaves in terminal bud develop a "hooked" appearance and die back at the tips and along the margins.

6. Leaves have a wrinkled appearance.

7. Sometimes young leaves remain folded.

8. A light green band is often evident along the margin of leaves.

9. Roots may be short and have many branches.

Magnesium

1. There is a general loss of green color which starts in the bottom leaves and gradually moves up the stalk depending upon the degree of deficiency. The veins of affected leaves remain green.

2. Cotton leaves will often turn a purplish-red color between the green veins.

3. The plant may show evidence of chlorosis.

4. Leaves are abnormally thin.

5. When deficiency is acute the affected tissue may dry up and die.

6. Leaves of plant are brittle and tend to curve upward, especially along the margins.

7. On trees the twigs are weak and subject to fungus infection. Leaves are often dropped prematurely. The tree will often die the following spring.

8. Stalks are weak. Roots are long branched.

9. A definite and sharply defined series of yellowish-green, light yellow or even white streaks throughout the entire leaf as with plants like corn.

Sulfur

1. A lack of the healthy green color of normal plants. Young leaves are light green in color, and have even lighter veins.

2. A reduction in protein content in plants like alfalfa.

3. Stalks are short and slender. Stems are small in diameter and are very hard and woody.

4. Slow, stunted growth.

5. In plants like potatoes there is often a spotting of leaves.

6. Fruit may be immature and light green in color.

7. Lower plant leaves may be a yellowish-green in color.

8. Although roots are well developed and extensive they are small in diameter.

HOW TO FIGURE FERTILIZER EQUIVALENTS CONVERSIONS BASED ON CONTAINED CALCIUM, MAGNESIUM AND SULFUR

Calcium Nitrate $Ca(NO_3)_2$ in pounds X 0.2442	=	Calcium (Ca) in pounds
Calcium (Ca) in pounds X 4.0942	=	Calcium Nitrate $Ca(NO_3)_2$ in pounds
Dibasic Calcium Phosphate ($CaHPO_4 \cdot 2H_2O$) in pounds X 0.2329	=	Calcium (Ca) in pounds
Calcium (Ca) in pounds X 4.2938	=	Dibasic Calcium Phosphate ($CaHPO_4 \cdot 2H_2O$) in pounds
Free Lime (CaO) in pounds X 2.4277	=	Calcium Sulfate ($CaSO_4$) in pounds

Calcium Sulfate ($CaSO_4$) in pounds X 0.4119	=	Free Lime (CaO) in pounds
Calcium Sulfate ($CaSO_4$) in pounds X 1.2647	=	Gypsum ($CaSO_4 \cdot 2H_2O$) in pounds
Gypsum ($CaSO_4 \cdot 2H_2O$) in pounds X 0.7907	=	Calcium Sulfate ($CaSO_4$) in pounds
Free Lime (CaO) in pounds X 3.0702	=	Gypsum ($CaSO_4 \cdot 2H_2O$) in pounds
Gypsum ($CaSO_4 \cdot 2H_2O$) in pounds X 0.3257	=	Free Lime (CaO) in pounds
Free Lime (CaO) in pounds X 1.7848	=	Carbonated Lime ($CaCO_3$) in pounds
Carbonated Lime ($CaCO_3$) in pounds X 0.5604	=	Free Lime (CaO) in pounds
Free Lime (CaO) in pounds X 0.7147	=	Calcium (Ca) in pounds
Calcium (Ca) in pounds X 1.3992	=	Free Lime (CaO) in pounds
Free Lime (CaO) in pounds X 1.8437	=	Tricalcium Phosphate $Ca_3(PO_4)_2$ in pounds
Tricalcium Phosphate - $Ca_3(PO_4)_2$ in pounds X 0.5424	=	Free Lime (CaO) in pounds
Calcium Carbonate ($CaCO_3$) in pounds X 0.4004	=	Calcium (Ca) in pounds
Calcium (Ca) in pounds X 2.4973	=	Calcium Carbonate ($CaCO_3$) in pounds
Calcium Carbonate ($CaCO_3$) in pounds X 0.7403	=	Calcium Hydroxide $Ca(OH)_2$ in pounds
Calcium Hydroxide $Ca(OH)_2$ in pounds X 1.3508	=	Calcium Carbonate ($CaCO_3$) in pounds
Calcium Hydroxide $Ca(OH)_2$ in pounds X 0.5409	=	Calcium (Ca) in pounds
Calcium (Ca) in pounds X 1.8487	=	Calcium Hydroxide $Ca(OH)_2$ in pounds

Calcium Hydroxide $Ca(OH)_2$ in pounds X 0.7568	=	Calcium Oxide (CaO) in pounds
Calcium Oxide (CaO) in pounds X 1.3212	=	Calcium Hydroxide $Ca(OH)_2$ in pounds
Sulfur Trioxide (SO_3) in pounds X 0.4005	=	Sulfur (S) in pounds
Sulfur (S) in pounds X 2.4972	=	Sulfur Trioxide (SO_3) in pounds
Sulfuric Acid (H_2SO_4) in pounds X 0.3269	=	Sulfur (S) in pounds
Sulfur (S) in pounds X 3.0587	=	Sulfuric Acid (H_2SO_4) in pounds
Magnesia (MgO) in pounds X 0.6032	=	Magnesium (Mg) in pounds
Magnesium (Mg) in pounds X 1.6579	=	Magnesia (MgO) in pounds
Magnesium Sulfate ($MgSO_4$) in pounds X 0.2020	=	Magnesium (Mg) in pounds
Magnesium (Mg) in pounds X 4.9501	=	Magnesium Sulfate ($MgSO_4$) in pounds
Magnesium Sulfate ($MgSO_4$) in pounds X 0.3349	=	Magnesia (MgO) in pounds
Magnesia (MgO) in pounds X 2.9858	=	Magnesium Sulfate ($MgSO_4$) in pounds
Epsom Salts ($MgSO_4 \cdot 7H_2O$) in pounds X 0.1636	=	Magnesia (MgO) in pounds
Magnesia (MgO) in pounds X 6.1135	=	Epsom Salts ($MgSO_4 \cdot 7H_2O$) in pounds
Epsom Salts ($MgSO_4 \cdot 7H_2O$) in pounds X 0.0987	=	Magnesium (Mg) in pounds
Magnesium (Mg) in pounds X 10.1356	=	Epsom Salts ($MgSO_4 \cdot 7H_2O$) in pounds

SOIL REACTION (pH) PREFERENCES
OF SOME NEW MEXICO PLANTS

Plant (Common Name)	Favorable pH Ranges							
	4.8-6.5	5.0-6.0	5.5-6.5	5.8-7.0	6.0-6.5	6.0-7.0	6.0-7.5	6.0-8.0
Alfalfa						x		
Alsike Clover						x		
American, Plum								x
Apple			x					
Asparagus						x		
Barley						x		
Beans							x	
Beans, Lima			x					
Beet, Garden				x				
Beet, Sugar								x
Bentgrass			x					
Blackberry								x
Blackberry (some varieties)		x						
Bluegrass, Kentucky								x
Broccoli						x		
Brome Grass								x
Cabbage						x		
Canna								x
Cantaloupe								x
Carnation								x
Carrot			x					
Cauliflower						x		
Celery					x			
Cherry								x
Chrysanthemum								x

Plant (Common Name)	Favorable pH Ranges							
	4.8-6.5	5.0-6.0	5.5-6.5	5.8-7.0	6.0-6.5	6.0-7.0	6.0-7.5	6.0-8.0
Clover (Trifolium)						x		
Corn						x		
Cotoneaster								x
Cotton, Upland			x					
Cowpea, common			x					
Cucumber								x
Daylily								x
Dewberry		x						
Douglas fir						x		
Eggplant						x		
Elm								x
Fescue, Sheep		x						
Forsythia								x
Foxtail, Meadow								x
Geranium								x
Gladiolus								x
Grape								x
Grass, Bermuda						x		
Grass, Orchard								x
Groundsel						x		
Hackberry								x
Hibiscus								x
Hollyhock								x
Honeylocust								x
Honeysuckle								x
Horseradish								x
Hydrangea								x
Juniper, common						x		
Juniper, creeping		x						
Kale								x
Larkspur			x					
Lettuce						x		
Lilac								x

Plant (Common Name)	Favorable pH Ranges							
	4.8-6.5	5.0-6.0	5.5-6.5	5.8-7.0	6.0-6.5	6.0-7.0	6.0-7.5	6.0-8.0
Locust								x
Muskmelon								x
Oats						x		
Okra								x
Onion						x		
Pansy								x
Pea, common								x
Pea, sweet								x
Peach								x
Peanut		x						
Pear								x
Pecan						x		
Peony								x
Pepper					x			
Petunia								x
Pine (many species)		x						
Plum, common								x
Poinsetta								x
Poplar								x
Potato	x							
Potato, sweet (some varieties)		x						
Potato, sweet (some varieties)						x		
Privet								x
Radish								x
Raspberry		x						
Red Clover						x		
Redtop						x		
Rhododendron		x						
Rose								x
Rye						x		
Snapdragon						x		

Plant (Common Name)	Favorable pH Ranges							
	4.8-6.5	5.0-6.0	5.5-6.5	5.8-7.0	6.0-6.5	6.0-7.0	6.0-7.5	6.0-8.0
Sorghum						x		
Soybean						x		
Spinach								x
Spruce		x						
Squash								x
Strawberries (most varieties)		x						
Sumac								x
Sweet Clover								x
Tamarix								x
Timothy						x		
Tomato						x		
Trefoil, Birds Foot						x		
Turnip								x
Verbena								x
Vetch						x		
Violet								x
Watermelon						x		
Wheat						x		
White Clover						x		
Willow								x
Willow, creeping		x						
Wisteria								x
Yucca								x
Zinnia								x

APPROXIMATE POUNDS PER ACRE OF SECONDARY PLANT FOOD NUTRIENTS
UTILIZED BY SOME NEW MEXICO CROPS

Crop	Acre Yield	Calcium (Ca)	Magnesium (Mg)	Sulfur (S)
Alfalfa Hay	4 tons	112-148	20-29	19-20
Apples	500 bushels	3-8	5	10
Barley (Grain and Straw)	40 bushels	7-9	4-5	7-8
Beans, dry	30 bushels	2-4	2-4	4-5
Bentgrass	2.5 tons		12	10
Bermudagrass (coastal), hay	8 tons	56-59	24-45	36-64
Bluegrass, hay	2 tons	14-16	7-13	5-17
Bromegrass	5 tons		10	20
Cabbage	20 tons	16-20	5-20	32-44
Clover-grass, hay	6 tons		30	30
Clover (Red), hay	2.5 tons	69	17	7
Corn (grain and stover)	100 bushels	18-40	11-33	11-22
Corn, silage	32 tons		50	30
Cotton (seed and lint)	1500 pounds	2-4	4-6	2-5

Crop	Acre Yield	Calcium (Ca)	Magnesium (Mg)	Sulfur (S)
Cotton (stalks, leaves and burs)	2800 pounds	39-59	9-11	4-7
Cowpeas (grain)	15 bushels	2	3	2
Cowpea, hay	2 tons	45-55	15-20	13
Grain Sorghum (grain and stover)	8000 pounds	45-65	36-45	10-38
Oats (grain and straw)	50 bushels	6-13	6-8	7-9
Onions	600- 50 pound sacks	11-22	4-7	29-36
Orchard Grass	6 tons		25	35
Peaches	600 bushels	3-4	6-8	2-3
Peanuts (nuts and vines)	2000 pounds	53-60	12-30	18-30
Potatoes, Irish (tubers)	400- 60 pounds bushels	3-5	6-10	6-9
Potatoes, sweet (roots)	300- 55 pound bushels	4-6	9-11	6-7
Rye (grain and straw)	30 bushels	2-10	3-4	6-7
Soybeans (grain)	40 bushels	6-7	6-9	4-7
Spinach	5 tons	10-12	5-6	4-5
Sugar Beets (roots)	15 tons	22-33	8-24	5-10
Timothy, hay	2.5 tons	18	6	5
Tomatoes	15 tons	5-12	7-8	4-10
Turnips	10 tons	11-12	4-6	16
Wheat (grain and straw)	40 bushels	7-8	5-9	6-8

REFERENCES

"Our Land and Its Care" - National Plant Food Institute

"Western Fertilizer Handbook" - The Pacific Northwest Plant Food Association and the California Fertilizer Association

"La Motte Soil Handbook" - reprinted in March, 1971

"Increase Crop Quality and Yields with Sul-PO-Mag" - Potash Division International Minerals and Chemical Corporation

"Magnesium and Sulfur - Essential Plant Food Elements" - International Minerals and Chemical Company

"Know the Plant Food Content of Crops" - The Potash Institute of North America