Secondary Macronutrients

The secondary macronutrients—calcium, magnesium, and sulfur—are generally not limiting to crop production in most Minnesota soils except under certain conditions.

Calcium

Calcium is available to plants as the Ca^{2+} ion. Calcium deficiency due to low soil calcium is rare, but may occur in acid sandy soils. Soils cropped to potatoes for many years may be low in calcium because liming is not recommended for this crop. Soil test results of less than 300 ppm calcium are considered low. For all crops except potatoes and blueberries, calcium needs can be met by liming according to soil pH. For potatoes where maintenance of acidity is desired, calcium needs can be met by applying low rates of lime (approximately 1000 lb/A) during the rotation year. An alternative is to apply calcium as gypsum (calcium sulfate—20% Ca) according to **Table 37**.

Some plants are susceptible to calcium deficiency even when adequate levels of calcium are present in the soil. For physiological disorders related to calcium deficiency (such as blossom end rot in tomatoes; tipburn in lettuce, cabbage, or cauliflower; black heart in celery; or bitter pit in apples) foliar calcium sprays may be beneficial. In soils where pH has been adjusted to 6.0 or above, additional soil applied calcium generally does not correct these physiological disorders. These disorders can often be related to cultivar, excessive ammonium fertilization, and/or excess or lack of water. For foliar sprays, apply 2-4 lb Ca/A. Calcium chloride at the rate of 5-10 lb per 100 gallons per acre or calcium nitrate at the rate of 10-15 lb per 100 gallons per acre should be applied directly to the sensitive tissue. Multiple applications are necessary to increase tissue calcium. Because of precipitation problems, do not mix calcium with sulfate or phosphate compounds.

Table 37. *Calcium recommendations for fruit and vegetable crops.*

Calcium Soil Test	Relative Level	Calcium to Apply
ppm		lb/A
0 - 150	low	200
151 - 299	medium	100
300 +	high	0

Magnesium

Magnesium is available to plants as the Mg^{2+} ion. Magnesium deficiency may occur in acid sandy soils. Soil tests less than 100 ppm magnesium are considered low. Deficiencies can be induced by high rates of potassium fertilizer on sandy soils low in magnesium. If magnesium deficiency is known or suspected, the use of dolomitic limestone is the best long-range approach. Apply low rates (approximately 1000 lb/A) if maintenance of soil acidity is desired. Other more immediately available sources of magnesium include potassium-magnesium sulfate (11% magnesium) or Epsom salts (10% magnesium). Recommended rates of magnesium based on a soil test are presented in **Table 38.** For in-season correction of magnesium deficiency, foliar sprays at the rate of 2-4 lb Mg/A are recommended (20-40 lbs of Epsom salts per acre). Two to three applications are required.

Table 38. *Magnesium recommendations for fruit and vegetable crops.*

Magnesium Soil Test	Relative Level	Magnesium to Apply	
		Broadcast	Row
ppm		---------- lb/A ---------	
0 - 49	low	100	20
50 - 99	medium	50	10
100 +	high	0	0

Sulfur

Sulfur is available to plants as the sulfate ion (SO_4^{2-}). Like nitrate, sulfate is susceptible to leaching on sandy soils. Sulfur deficiency is most common on sandy low organic matter soils. Soil tests for sulfur are only accurate for sandy soils. If deficiency is known or suspected, refer to **Table 39** for sulfur soil test recommendations. The sulfate form of sulfur is the preferred form to use as fertilizer.

Table 39. *Sulfur recommendations for fruit and vegetable crops.*

Sulfur Soil Test	Relative Level	Sulfur to Apply	
		Broadcast	Row
ppm		---------- lb/A ----------	
0 - 6	low	20-30	10-15
7 - 12	medium	trial only	trial only
12.1 +	high	0	0

Micronutrients

Micronutrients, which include boron, chlorine, copper, iron, manganese, molybdenum, nickel, and zinc, are required in smaller amounts than the other essential nutrients. Generally, soils contain sufficient levels of micronutrients to meet crop demands; however, in some areas micronutrient shortages occur and may limit yields. Some crops have a higher demand for certain micronutrients than others and should be considered in determining whether a micronutrient fertilizer should be applied. The relative response of various fruit and vegetable crops to micronutrients is presented in **Table 40.**

Boron

Boron is taken up by plant roots as the neutral molecule H_3BO_3. Deficiency of boron is most likely on sandy soils low in organic matter. Excessive rainfall or irrigation may leach boron from sandy soils. A suspected boron deficiency should be confirmed by soil and plant analyses before a boron fertilizer is applied since excessive boron can be highly toxic to plants. Boron recommendations are presented in **Table 41**. For in-season correction of boron deficiency, foliar sprays at the rate of 0.2 to 0.4 lb B/A are recommended. Multiple applications are usually required.