

Stoller Group

*Crop Health
Leader*



Plant Health & Nutrition

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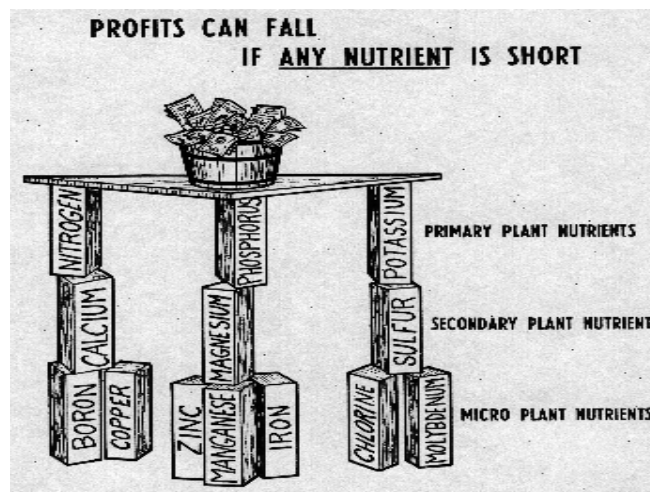


Plant Health and Nutrition

Ever heard, “you are what you eat”? It’s the same for your crops. Crop health is a function of what it takes up. We see obvious signs of compounds that are bad for the plant such as herbicide uptake and we see positive effects such as the impact of nutrition on plant health. The health of a crop can only be as good as its weakest link. This is referred to as Liebig's Law or the Law of the Minimum and is illustrated below.



Plants require 16 nutrients all of which have significant impact on the plant’s health and ability to ward off diseases and other damaging influences. These 16 nutrients are divided into 3 categories; (1) Primary (macro) nutrients, (2) Secondary nutrients and (3) Micronutrients. The following Figure illustrates nutrients in each of the 3 categories and their importance to a stable profitable crop.

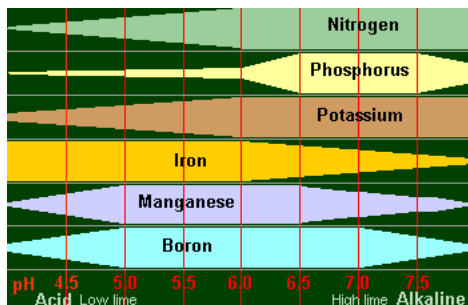


Plant nutrition has a big effect on the plants’ susceptibility to disease. Micronutrients regulate the plant's physiology. Only small amounts of micronutrients are needed to mobilize a plant's disease resistance, but it is critical. In studies at four Purdue agricultural research farms and at agronomy centers in Canada, researchers found that micronutrient deficiencies have both a direct and indirect impact on crops.



Factors Affecting Nutrient Availability

Micronutrient availability is frequently reduced by high *soil pH*, a fact of the many soils across Canada. Alkalinity and *pH* influence the availability of micronutrients as acidity/*pH* goes down the availability of Boron (B), Chloride (Cl), Cupper (Cu), Iron (Fe), Manganese (Mg) and Zinc (Zn) increases. A *pH* of 6.5 is considered optimum for nutrient availability. Below is a figurative illustration of the *pH* affect.



Increased crop yields and cropping frequency, have resulted in the removal of nutrients. In fact, nutrient removal is at its highest level in history. The following table quantifies nutrient removal with various crops.

Comparison of Total Ca, Mg, S and P Crop Uptake

		Nutrients Taken Up, lb/acre			
Crop	Yield/Acre	Ca	Mg	S	P
Corn	180 bu	44	58	30	44
Soybeans	60 bu	26	27	25	29
Wheat	70 bu	18	21	18	20
Alfalfa	8 tons	175	40	40	35
Fescue	3.5 tons	30	13	15	26
Tomatoes	800 cwt	30	36	54	37
Sugar beets	25 tons	N/A	67	37	14

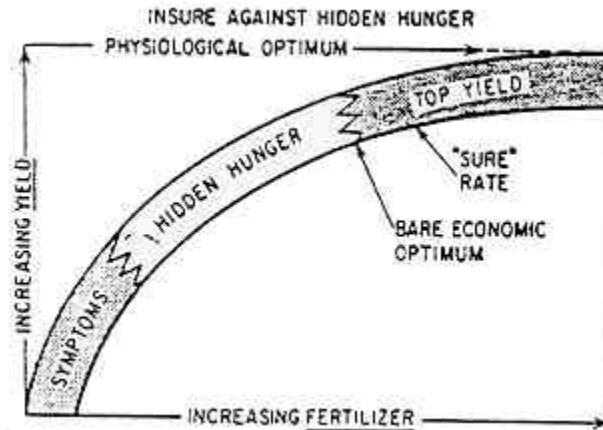
Other factors that reduced micronutrient availability include; soil densification as a result of organic matter loss and change of clay stability, adverse effects of some herbicides on root morphology and reduced soil disturbance from reduced tillage practices, which can limit root development and penetration.

Another reason for nutrient disorders is change in practices. The amount of sulfur dioxide returned to the atmosphere is now restricted by government regulations. Most of the sulfur is now removed from natural gas and catalytic converters in new automobiles remove most of the sulfur that was previously returned to the cycle.



Appearance

Nutrient deficiencies may not be apparent as striking symptoms such as chlorosis (yellowing) on the plant, especially with mild deficiencies. However, significant reductions in crop yields can occur with such deficiencies. Symptoms aren't always apparent. Scientists call the phenomenon "hidden hunger". Deficiencies can only be detected with plant tissue analysis or yield decline. Crop malnutrition occurs more frequently than might be believed.



Prediction and detection of the onset of new micronutrient limitations to productivity is complex due to the number of interacting factors that can initiate deficiencies. Insurance application of micronutrients is becoming more common. Farmers who suspect their crops are “nutrient-needy” or “nutrient starved” apply nutrients to the soil or crop. Frequently, the nutrient application can be combined with a seed treatment or as a foliar spray along with plant protection products.

Micronutrient deficiencies are difficult to diagnose. Symptoms vary from crop to crop, and overlap with viral and disease symptoms. Latent nutrient deficiencies have no visible symptoms but crops will not respond well. Yields will be suppressed until the deficiency state is corrected. The majority of the micronutrients are not mobile in the plant and therefore deficiency symptoms are usually found on new growth. See table below for generalized symptoms.



Generalized Symptoms of Plant Nutrient Deficiency or Excess

Nutrient	Visual Deficiency symptoms
Calcium	Deformation of younger leaves, then a disintegration of terminal growing areas.
Magnesium	Lower leaves show symptoms first, yellowing from the tip and eventually falling. Veins remain green longer than the interveinal areas.
Sulfur	Initial yellowing of young leaves spreading to whole plant
Iron	Initial distinct yellow or white areas between veins of young leaves leading to spots of dead leaf tissue.
Manganese	Interveinal yellowing or mottling of young leaves.
Zinc	Interveinal yellowing on young leaves; reduced leaf size and may deform.
Boron	Death of growing points and deformation of leaves with areas of discoloration. Stunted growth and poor root development.
Chloride	Stunting, tip wilt, high amino acid levels in various crops.
Copper	Leaf tip death, severe reactions to some herbicides, unusual crop lodging, melanosis (browning) of upper stem and heads, sterility and low-test weight.
Iron	Stunting, chlorosis (yellowing) and short and highly branched roots
Molybdenum	Stunting, chlorosis, similar to nitrogen deficiency, yellowing of plant
Secondary nutrients	Micronutrients

Response

Micronutrients are key players in many of the processes important for plant growth. Some crops benefit more from certain nutrients. For example, the following lists the crop and the degree of response to various nutrients.

Relative Responsiveness of Selected Crops to Micronutrients

Crop	B	Cu	Mn	Zn	Su	Ca	Mo	Fe
Alfalfa	High	High	Low	Med	Low	Med	High	Med
Apple	High	High	Low	Med	Low	High	High	Low
Barley	Low	High	High	High	Low	Med	Med	High
Beans	High	Med	High	High	Low	High	Med	High
Canola	High	Med	Low	Med	High	High	Med	Low
Clover	Med	Med	Med	Med	Low	Med	High	Med
Corn	High	Med	Low	High	Low	Med	High	Med
Flax	Low	Low	Low	High	Low	Med	Low	Low
Forage	Med	Med	Low	Med	Low	Med	Med	High
Lentil	High	Med	High	Med	Med	High	High	Low
Oat	Low	High	High	Med	Low	Med	Med	Med
Onion	Med	High	High	High	Low	High	Med	Med
Pea	High	Med	High	Med	Med	Med	High	Med
Potato	High	High	High	High	Low	High	Med	Low
Rye	Low	Low	Low	Med	Low	Med	Med	Med
Soybean	Med	Med	High	Med	Low	High	High	Med
Sugar Beet	High	Med	High	Med	Low	Med	Med	High
Sunflower	High	Med	High	High	Low	Med	Med	Low
Tomato	High	High	Med	Med	Low	High	High	High
Wheat	Low	High	High	Med	Low	Med	Med	Med



Nutrient Role and Deficiency Symptoms

Secondary Nutrients

Calcium (Ca)

Calcium is a part of cell walls and regulates cell wall construction. Calcium is also intricately involved in a large number of plant growth processes including pest resistance. The following images denote Ca deficiency in various crops.



Cork spot in apple due to Ca deficiency



Ca deficiency in alfalfa



Ca deficiency in tomato



Ca deficiency in corn

Magnesium (Mg)

Magnesium is involved in the manufacture of plant chlorophyll and so it is critical for photosynthesis. It is also involved in a large number of enzyme systems. Magnesium, from a disease standpoint, plays a critical role.



Mg deficiency in wheat



Mg deficiency in corn

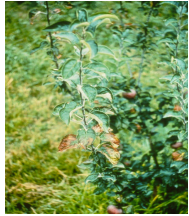




Mg deficiency in soybean



center rows Mg deficient



Mg deficiency in apples



Mg in grapes



Mg deficiency in alfalfa



Mg deficiency in sugar beet
Front: healthy; Rear Mg deficient



Mg deficiency in cabbage



Mg deficiency in celery



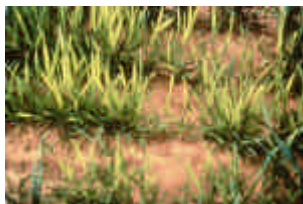
Mg deficiency in onion (right)
left healthy; right Mg deficient



Mg in kidney bean

Sulfur (S)

Sulfur is a part of certain amino acids and many proteins. Sulfur is important in the development of root growth and seed production. Wheat requires a high amount of supplemental sulfur. One reason for this need is that wheat experiences its most rapid growth during early spring when the rate of S release from soil organic matter is quite slow.



S deficiency in wheat



S deficiency in canola





S deficiency in corn



S deficiency in alfalfa



S deficiency in lettuce



S deficiency in kidney bean

Micronutrients

Boron (B)

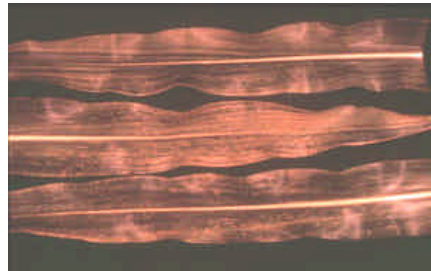
Boron is instrumental in cell wall processes and is important in sugar transport within the plant. It has a role in cell division, and is required for production of certain amino acids. Boron's function is similar to calcium; calcium has a huge effect on plant growth especially on auxin, the major growth-controlling hormone in plants. Boron enhances phosphorous uptake and is very important for seed and grain production, especially during production of pollen and sugars.



B deficiency in alfalfa



B deficiency in corn



B deficiency in canola





B deficiency in clover



B deficiency in sugar beet

Copper (Cu)

Copper is a component of enzymes involved with photosynthesis. Copper is very important in cell membrane functionality such as in electron transport (necessary for growth). Copper is important in ensuring sufficient sugars for growth in the vegetative stages of the plant. Auxin, gibberellin and cytokinins also interact in regulation of sugars. Copper is very important in flowering and lignin formation. Copper affects grain, seed and fruit formation, all processes regulated by auxin, cytokinin and gibberellin.



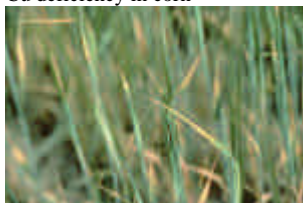
Cu deficiency in barley



Cu deficiency in corn



Cu deficiency in onions



Cu deficiency in wheat



Manganese (Mn)

Mn is a key component of energy regulation, which plays a critical role in photosynthesis. It also activates enzymes. Manganese helps nutrients across membranes. Manganese is heavily involved in photosynthesis. A deficiency of manganese will greatly reduce auxin levels, the main plant growth regulating hormone. Sugars are also greatly reduced with manganese deficiency and plants are more prone to frost damage. A correct balance of manganese is very important especially since too much manganese can also reduce auxin levels.



Mn deficiency on broccoli



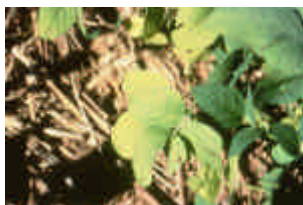
Mn deficiency on celery



Mn deficiency in corn



Mn deficiency in grape



Mn deficiency in soybean



Mn deficiency in oats

Zinc (Zn)

Zinc is a microelement involved in a large number of physiological processes including synthesis of the amino acid, tryptophan and the level of auxin, the most influential hormone in crop plant growth. Hormones regulate a large number of genes on the DNA. Zinc is involved in regulation of DNA and RNA synthesis regulated by a hormone like auxin. Sugar manufacture and use by the plant during photosynthesis is highly regulated by hormones such as auxin, gibberellin and kinetin. Zinc is part of a system that protects the plant's membrane from any escaped high energy radicals produced during the capture of light energy. Zinc is also highly involved in sugar (carbohydrate) use and protein synthesis. Zinc also helps reduce the degradation of the protein synthesis machinery (i.e. keeps the workers in plant healthy). Proteins are the "workers" in plant tissue, the molecules that get things done. Zinc is in very high concentrations in pollen tubes and interacts with hormones regulating pollination and seed formation.

Research from many sources indicates that the phosphorous (P) to Zn ratio in leaf tissue should be 100-150:1. When the P content of a plant increases so must the Zn concentration. The following figure illustrates the P/N relationship.



Phosphorus/zinc relationship



Zn deficiency in Dry edible beans



Dry beans: Front no Zn; Back applied Zn



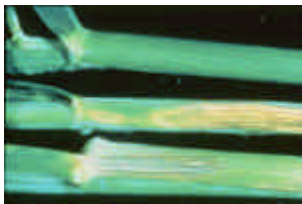
Zn deficiency in soybean



Zn deficiency in Kidney beans



Zn deficiency in onions



Zn deficiency in wheat



Zn deficiency in durum wheat



Zn deficiency in corn



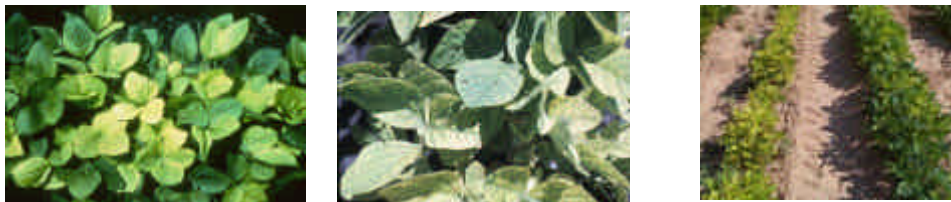


Iron (Fe)

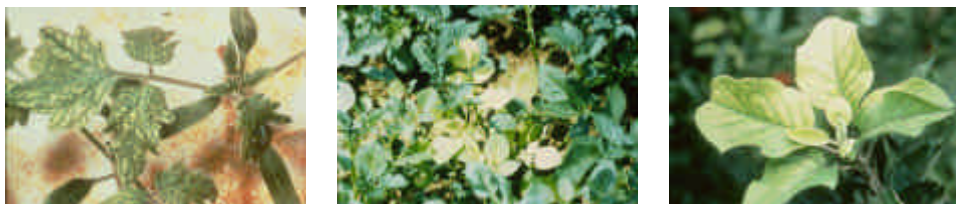
Iron also plays a key role in chlorophyll development, which in turn drives photosynthesis. Iron is important in energy transfer/use in chloroplasts and mitochondria enhancing hormonal effects such as with auxin. Iron is important in cell wall and lignin formation throughout the plant. Iron improves protein synthesis especially in the chloroplasts. Eighty percent of iron is in the chloroplasts. Iron along with a hormone like auxin is important in phloem loading of sucrose.



Fe deficiency in corn



Fe deficiency in soybean



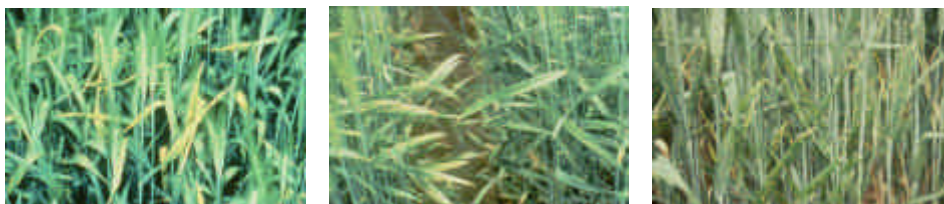
Fe deficiency in tomato

Fe deficiency in potato

Fe deficiency in apples

Chloride (Cl)

Plants use chlorine as the chloride ion. Chloride is useful as a charge balancing ion and for turgor regulation, keeping plant cells more free of infection by disease organisms. It is essential for photosynthesis. Chlorine is an important plant nutrient; optimal growth of plants is at concentrations between 350 – 1200 mg/Kg dry weight (DW). Chlorine aids oxygen evolution in plants and is involved in ATP (energy formation). A number of hormones such as auxin and gibberellin are very important in these processes. Chlorine is necessary in maintaining pH levels in various parts of the cell.



Cl deficiency in wheat

healthy vs deficient

deficiency leaf spot



Molybdenum (Mo)

Molybdenum is an important component of nitrogen fixation and legume response is often marked. Molybdenum is a component of enzymes involved with changing the nitrogen form for plant use. Nitrogen can have a large influence especially on cytokinin but also other hormones. In tomato fruit, molybdenum increases ascorbic acid and organic acids and decreases nitrate content. Molybdenum deficiency can be widespread in some crops such as soybean. Interestingly, studies have been done indicating the quantity of molybdenum in the seed can affect yield. A seed molybdenum content of 0.05 mg/Kg DW yielded 1,500 kg/Ha whereas when seeds had 20mg/Kg yields were 2,300.



Mo deficiency in wheat



Mo deficiency in cauliflower (similar in canola)



In summary, it is important to address crop nutrition with a holistic view, recognizing each nutrient plays a critical role and fortification of all nutrients must be addressed. Hidden hunger must be in the nutritional decision making to avoid limiting crop potential.

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Acknowledgements;

McGill University web site www.nrs.mcgill.ca



Plant Health and Nutrition

Quiz.....

See if you can identify the nutrient deficiency.



1. _____



2. _____



3. _____

4. _____



5. _____



Match the correct deficiency by filling in the above 5 blanks with a deficiency listed below.

- Iron (Fe) deficiency
- Magnesium (Mg) deficiency
- Copper (Cu) deficiency
- Boron (B) deficiency
- Zinc (Zn) deficiency