RELATIONSHIP BETWEEN MINERAL CONTENT AND TUBER QUALITY [1]

by
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Mineral imbalance in potato tubers can lead to increased incidence of physiological disorders. The initiation of hollow heart, a common physiological disorder, is known to be associated with environmental stress. Under conditions of rapid vine growth the physiological balance of the plant is altered and top growth is produced at the expense of tubers. Calcium is relatively immobile and it is rarely shifted or relocalized within the plant, whereas, potassium and other elements are redistributed readily.

Calcium follows the water paths within the plant, and therefore is taken primarily to the leaves where most of the transpiration takes place. Under stress conditions, when plants are not getting enough calcium, leaves out-compete tubers. This leads to mineral imbalance during early stages of tuber development. Cultural practices therefore influence the ability of the developing tuber to get its share of mineral elements, particularly calcium. Calcium plays a major role in protecting cell wall structure and membrane compartments in the tuber.

Our study involved a comparison of mineral distribution, particularly potassium (K^+), sodium (Na^+), magnesium (Mg^{++}) and calcium (Ca^{++}) within potato tubers (Figure 1). In a healthy tuber, the concentration of potassium was highest in the bud end (15,000-20,000 micrograms/gram solid) and lowest in the stem end (10,000-12,000 micrograms/gram solid). No such gradient was observed for the other three cations. In tubers showing hollow heart and other types of localized tissue damage, there was an imbalance in the mineral distribution. There was a positive correlation between low calcium content and localized tissue injury. Our studies show that calcium-deficient tubers are more susceptible to various disorders than tubers receiving normal amounts of this nutrient.

Relationship between excessive nitrogen and stress

Potato plants grown with super abundant nitrogen supplies are dark green in color and usually show an abundance of foliage with a poorly developed root system. In these plants the sugar and hormone transport to the developing tubers is altered. Under stress conditions, plants with poorly developed root systems are more vulnerable to various types of physiological disorders. A proper balance between vine growth and underground parts such as roots and tubers must be maintained by proper application of nitrogen fertilizers to avoid mineral imbalance in the tuber.

Competitive effects in cation uptake and distribution

The nitrogen nutrition under which the plant is grown has significant influence on calcium uptake and distribution. Ammonium nitrogen reduces calcium uptake and movement. In addition, calcium uptake from the soil has been shown to be reduced by other positively charged cations such as K^+, NH_4^+ and Mg^{++}. Calcium is the most immobile element and its transport is predominately upwards from the roots to the meristematic zones. There is little or no redistribution of calcium after its deposition in an organ. This immobility and unique pattern of calcium transport has an important consequence on plant health, particularly in the rapidly

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developing tubers because any interference in calcium supply to or from the roots can lead to temporary calcium deficiency. Rapid vine growth under these circumstances can drastically alter the growth balance and increase the incidence of physiological disorders due to mineral imbalance.

Role of calcium in physiological disorders

Many of the physiological disorders afflicting storage organs, sush as potato tubers, are related to the calcium content of the tissue. Improving their calcium content normally diminishes the occurrence of the disorder. Much of the pectic acid in the cells of potato is apparently in the form of calcium pectate. Thus, proper supply of calcium ions (Ca^{++}) has the effect of increasing the rigidity of cell walls by the formation of calcium pectate, with the divalent calcium forming the "bridges" (Figure 2). During the initiation of physiological disorders such as hollow heart and brown center, the cell wall rigidity is lost and the cells are no longer protected. Results indicate that calcium pectates of the middle lamella of cell walls act to cement the adjacent primary walls together so that cells of developing tubers remain bound to one another. The pectic substances in calcium-deficient tissues are more easily hydrolized by pectolytic enzymes than those in normal tissue. These results suggest that increased calcium content in the tubers can enhance resistance against physiological disorders, such as hollow heart, and other types of localized tissue injury.

Summary

In conclusion, the following are the major causes of low tuber calcium:

1. Poor nutrition - nutrient imbalance, calcium deficiency
2. Excessive leaf growth - top growth draws most calcium away from the tuber
3. Leaf:Tuber ratio - tuber load can change nutrient balance
4. Poor water management - stress can lead to mineral imbalance

Figure 1. Mineral content of healthy Russet Burbank potato.

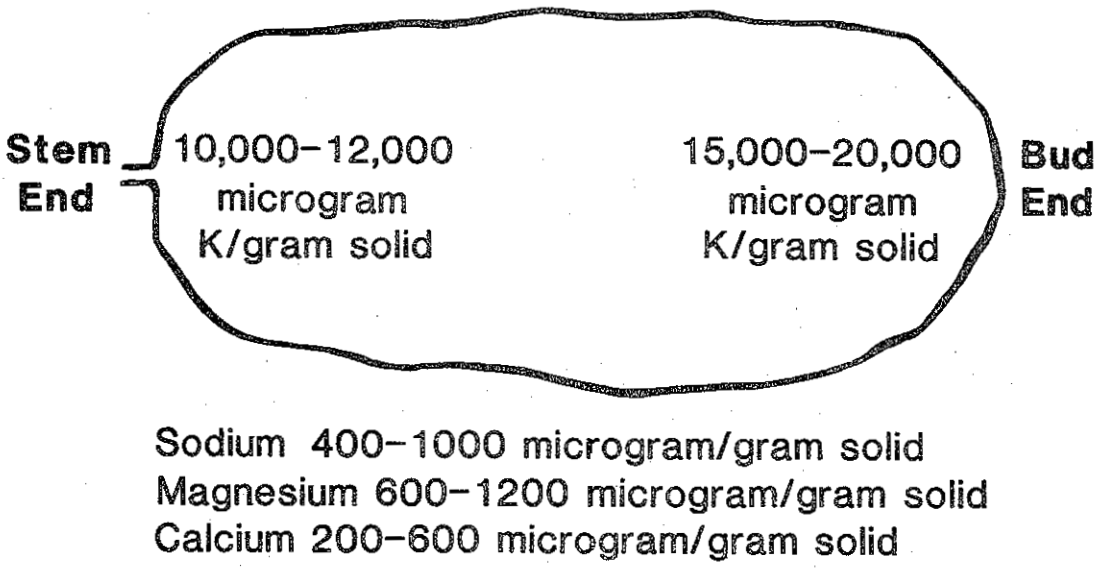

Figure 2. Interconversions of pectic substances in potato cell walls.