Calcium Nutrition of Potatoes... Problems and Potential Solutions

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Adequate calcium (Ca) is a critical aspect of the mineral nutrition of potatoes. Calcium is involved in both the structure and function of all plant cell walls and membranes. Inadequate supplies of calcium cause growth abnormalities like internal brown spot and hollow heart. Adequate calcium nutrition can also improve skin color in red potatoes, while reducing problems with blackspot bruising and buckskinning. Abundant tissue calcium also increases the tubers’ resistance to attack by soft rot bacteria during storage and may improve the performance of seed potatoes.

The soil test recommendation for Ca for potato production is around 300 ppm (600 #/a) and most soils in Saskatchewan contain 2 or 3 times the critical level of Ca. Deficiencies can occur, especially on the sandy soils preferred in potato production. Growers are urged to have the Ca levels of their soils tested - especially when moving onto a new field. Problems with calcium deficiency may still arise in fields that appear to have abundant Ca. This reflects the nature of Saskatchewan soils as well as manner in which Ca is absorbed and subsequently allocated within the potato plant.

While Saskatchewan soils tend to be rich in Ca, they may also contain very high levels of potassium (K). This superabundance of K in the root zone may competitively interfere with Ca uptake.

Most Ca uptake occurs near the tips of newly formed roots - consequently, anything that interferes with development of new roots interferes with calcium uptake. Environmental stresses like heat, cold and drought slow development of new roots, thereby leading to calcium stress. However, the most common cause of reduced root growth is the rapid development of other tissues - as these rapidly growing tissues effectively out-compete the roots for the energy resources needed for growth. In potatoes, root development slows dramatically as the tubers begin to set and expand. This reflects the fact that at tuber set, the plant diverts the majority of its available energy resources to support development of the tubers (Fig. 1). This creates a calcium shortage - precisely at the time when the calcium is needed most in the developing tubers.

Even if calcium uptake is adequate, calcium deficiencies can arise in the tubers due to the pattern of allocation of calcium within the plant. Calcium movement within the plant is governed by water movement - tissues that use the most water due to evapo-transpiration accumulate the most calcium. The leaves and stems of potato contain about 5X as much calcium as the tubers (Fig. 2). This reflects the fact that the leaves and stems lose far more water than the tubers, because the tubers are constantly surrounded by moist soil.

Fig. 1. Growth pattern for potato (Source: Manitoba Agriculture http://www.gov.mb.ca/agriculture/index.shtml)

Fig. 2. Calcium uptake pattern for potato (Source: Manitoba Agriculture http://www.gov.mb.ca/agriculture/index.shtml)
The natural of uptake and allocation of calcium explains why calcium deficiencies can arise in situations where there is abundant Ca available in the soil. This also explains why it is difficult to develop fertility management strategies to treat this problem. Dr. Jiwan Palta of the University of Wisconsin has been researching methods to management calcium fertility problems in potatoes for over decade. His finding can be summarized as follows;

1) supplying Ca to the main root system is largely ineffective as a means for enhancing Ca levels in the tuber. This reflects the fact that potato tubers do not rely on the main root system for their Ca needs. Instead, the tubers appear to absorb Ca from their immediate vicinity using a system of fine roots that grow at the junction between the tuber and the stolon or directly out of the tuber surface.

2) consequently, the key to alleviating problems with Ca deficiencies in the tubers is to increase the levels of soluble, plant available Ca in the immediate vicinity of the developing tuber. This Ca is available for absorption by the tuber root system.

3) because of 1) and 2) above, pre-plant broadcast applications of calcium fertilizers tend to improve Ca levels in the leaves and stems, but not the tubers. Pre-plant applications of Ca are therefore only effective in situations where a soil test indicates a general deficiency of soil calcium. Pre-plant banding may be more effective if the fertilizer is positioned so that it increases the soil Ca levels in the immediate vicinity of the developing tubers. Recommendations out of P.E.I. suggest the application of 20-50 # Ca/a as CaNO3 in bands below and to the side of the seedpiece.

4) Foliar applications of Ca do not alleviate problems with Ca shortages in the tubers. There is some limited evidence that foliar applications of Ca (0.5 to 1.0 #/a) beginning at flowering will improve the Ca status of the tops, thereby enhancing general crop health.

5) The most effective approach to improving Ca levels in the tubers appears to be the mid-season application of Ca via side-banding or more practically through the irrigation system. Treatments begin at tuber set (early flowering) and continue at 2 week intervals for the next 6-8 weeks (3-4 applications). The calcium must be in a water soluble form (ie; CaCl2 or CaNO3) so that it can move into the vicinity of the developing tubers. Side-banded granular fertilizers must be irrigated in. The total amount of Ca required is still a matter of debate. Palta doubled tuber Ca levels by applying a total of 160 # Ca/a split over 4 applications in a moderately Ca deficient sandy soil. It should be noted that applying this amount of Ca as CaNO3 also delivers 125 # N/a, which may be wasteful or potentially problematic in areas with a short growing season. Less frequent or more diluted Ca treatments may be adequate in situations where less dramatic improvements in Ca nutrition are required.

6) Although Ca fertilizer treatment only rarely alter yields, they may affect tuber size distribution. Palta found that heavy applications of Ca occasionally reduced tuber set, resulting in a larger than average tuber size distribution. Research at the University of Saskatchewan looking at pre-plant and split applications of Ca on Norland and AC Peregrine growing on a Ca rich soil found an increase in average tuber size in one of two cropping seasons.