The Calcium Nutrition of Cotton

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Calcium, a macro nutrient element, plays important roles in every phase of the growth and development of the cotton plant.

Calcium and Seedling Growth

When germinated on media low in calcium, cotton seedlings developed symptoms which are similar to those caused by certain fungi. Radicles of such seedlings became water soaked in appearance and tissue breakdown occurred rapidly. In many cases stem tissue collapsed. This condition was correctly diagnosed as calcium deficiency. Cotton seed is notably low in calcium content thus adequate calcium absorption must develop very early in the life cycle of the plant to avoid serious deficiency.

In cotton seedlings calcium uptake can be detected five days after hydration of the seed. For the production of strong fruitful plants calcium absorption must continue through the entire life cycle. In experiments in which 45 day old cotton plants were transferred from complete to calcium deficient solutions, the plants were permanently wilted within eight days after the transfer. In contrast, similar plants continued growth for considerable periods and even produced bolls when transferred to nitrogen or potassium deficient solutions. The rapid wilting of the calcium deficient cotton plants can be attributed to membrane damage in cells of the roots associated with water uptake. Calcium is essential for the functional integrity of root cell membranes, especially the plasmalemma. Calcium deficiency thus causes membrane damage and the failure of the nutrient ion uptake mechanisms.

In addition, the above observation is associated with the translocation pattern of calcium in plants. Following absorption, calcium moves up the plant with the water stream in the xylem. This movement is strongly influenced by factors associated with rapid transpiration. Thus, increasing light intensity and temperature and decreasing the relative humidity promote calcium translocation and accumulation in the aerial portions of the cotton plant. Once in the leaves, calcium is fixed and cannot be redistributed to another plant organ. With the continual fixation of calcium in tissue associated with high transpiration, it becomes essential that a daily supply of calcium be available for absorption by the roots to support normal growth and fruit development.

Carbohydrates and Calcium

Calcium is important in the translocation of carbohydrates which are the energy supply for plant cells. In calcium deficient cotton plants, carbohydrates accumulate to very high levels in the leaves. With the cessation of carbohydrate movement from the leaves, the carbohydrate content of stems and roots decreases to extremely low levels. With such a reduced energy supply the normal functioning of calcium deficient roots is impaired.

Experiments conducted on the influence of calcium deficiency on carbohydrate distribution in whole cotton plants. The translocation of radioactive carbon sucrose (14C sucrose) in excised cotton roots, and the translocation of photosynthetically fixed 14C all support the conclusion that calcium plays a major role in carbohydrate translocation.

Adequate calcium is necessary for normal cell wall development. Roots of cotton grown in solutions containing high levels of calcium produced vascular tissue cells which had strong, thick walls. In contrast, cells from roots of the plants grown in the absence of calcium were weak and thin and rapidly lost all semblance of structure. The limitation of secondary cell wall thickening could be associated with the lack of carbohydrate translocation in calcium deficient plants.

Calcium and Salinity

About 25 to 30 percent of irrigated land in the Western United States is affected by salinity. It has been shown that calcium can offset to some extent the detrimental effects of high sale (NaCl) concentrations on the growth of Brittle Wax Bean. Similar results have been obtained with cotton even though cotton is much more salt tolerant than beans.

With increased salinity, the calcium requirement to produce maximum root growth increased. In sand culture experiments cotton plants grown under conditions of high salt and low Ca displayed symptoms of both salt damage and Ca deficiency. Leaf burning at the tips and margins, typical symptoms of salt damage, was evident and petiole collapse, an indication of calcium deficiency was apparent. Other plants grown at the same low calcium level but in the absence of salt appeared normal. Thus high NaCl may induce calcium deficiency symptoms under conditions of marginal calcium supply. With high levels of NaCl, increasing the calcium level had a very beneficial effect on the appearance of the plants and resulted in an 80 percent increase in vegetative dry weight. With these results, it can be concluded that within certain limitations increasing calcium supply tends to increase the salt tolerance of cotton.

Fruiting

Calcium is important in fruiting of cotton. Measurements of fruiting index (dry weight of bolls/dry weight of stems + leaves) serve to illustrate the productive efficiency of a plant under an even set of conditions. In an experiment in which 45 day old cotton plants were transferred from complete to low calcium nutrient solutions, fruiting activity stopped. Fruiting index measurements made at 90 days were 0.89 and 0.06 for the control and low calcium treated plants, respectively, In other experiments using cotton plants grown under varying levels of calcium, the fruiting index increased with each increment of added calcium. The latter experiments were compounded by the imposition of salt stress. Even so, the beneficial effect of increasing calcium was apparent at each salt concentration employed.

Summary

It is apparent that calcium serves as a major nutrient cation throughout the entire life cycle deficiency very soon after germination. Absorption of other essential ions is dependent upon an adequate supply of calcium. Membrane integrity and cell wall structure are closely associated with calcium nutrition. The translocation of carbohydrates requires a continual supply of calcium and the fruiting activity of the cotton plant is strongly influenced by the level of the element in the growth media. Calcium serves to increase the salt tolerance of cotton and other plants. These and possibly other functions of calcium in the physiology of the cotton plant serve to emphasize the need for maintaining adequate levels of calcium in our soils.

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