Calcium Uptake and Mobility: Effects on Kiwifruit Quality Using an Amino Acid Chelate.

Global competition is increasing the pressure on agriculture to produce higher quality, affordable products. The grower who prospers in the future must use his resources productively, manage his risks wisely, and maximize his returns on crop investments. Fertilisers are an important investment each grower makes. In order to maximise the returns on this investment, growers must balance the needs for nitrogen, potassium, calcium and phosphorous with the crops' requirements for secondary and micro nutrients. Without adequate amounts of each element in balance available at each growth stage, the maximum potential of the crop cannot be achieved.

Mobilisation of minerals from the soil, and corresponding uptake by the root, are related to the quantity of root surface that comes in contact with the mineral[1]. Because plants sometimes grow at rates that are faster than the ability of the roots to absorb and translocate minerals to the critical leaf and/or berry tissues, foliar sprays can often help overcome a deficiency and help maintain optimum nutritional levels of those critical tissues. Foliar application can be a useful adjunctive method of plant nutrition.

The Role of Calcium

For many years, there has been increasing interest in the use of calcium foliar sprays due to the beneficial effect Calcium has on fruit quality and shelf life. Calcium is an extremely important element in maintaining the strength of stems and stalks of plants. This mineral also regulates the absorption of nutrients across cell membranes. Calcium plays an important role in plant cell elongation and division, structure and permeability of the cell, nitrogen metabolism and carbohydrate metabolism[1]. Calcium itself is non-toxic, even in high concentrations, and serves as a detoxifying agent by tying up toxic compounds and maintaining the cation-anion balance in cells. Additionally, calcium is part of the cell wall, acting as the cement that binds the cell walls together. It is one of the most significant factors affecting firmness and storage life of fruit.

Generally fruit quality is associated with climate, soil conditions, tree characteristics, vine characteristics and cultivation practices[2]. However, deficiencies of elements such as calcium can manifest themselves as early as fruit set and continue to exist if untreated throughout the whole season. Calcium deficiency at an early stage of fruit development restricts cell division and produces disturbances in the structure of cell walls. The physiological role of this element is to of bind together neighbouring cell walls, maintaining integration and semi-permeable properties of membranes.

Movement of Calcium

In kiwifruit, as in most fruits, storage quality is related to calcium concentration, and many disorders are associated with low fruit calcium status. Previous studies show that after an early rise fruit calcium concentration decreases, as calcium influx ceases by the mid-growth stage, whereas volume growth continues until harvest[3]. Calcium transport to the fruit is exclusively via the xylem as calcium is not phloem mobile. Therefore, the amount of calcium that enters the fruit is related to the fruit transpiration rate, and the vascular efficiency of the xylem. The question is why the xylem contribution to growth is very small or negligible in late fruit growth stage. Many studies have highlighted that calcium accumulation is related to fruit transpiration rates. In fact, the reduction of transpiration rate in kiwifruit is coincidental with the calcium accumulation stoppage[4].

It is well known that in developing fruit, there is a shift between xylem and phloem supply balance. From mid season until harvest, the contribution to growth is almost phloem dominant[5]. Therefore, how is an element such as calcium going to be transported into the fruit if the primary mechanism for its movement, the xylem, undergoes reduced functionality?

Previous Calcium trials

Due to the relative immobility of calcium in the plant, strategies to increase fruit calcium levels usually involve direct application of calcium to the fruit, either through foliar sprays or fruit dipping. This indicates that calcium can move through the fruit flesh through cracks and/or openings in the fruit skin. Trials conducted by Hort Research with calcium chloride found that applications of this product at concentrations of greater than 0.5% caused damage to Hayward and Hort16A leaves, causing decay and early leaf drop. Calcium chloride also caused fruit damage where direct applications were made to young fruit. The trials did conclude, however, that there was some improvement in fruit calcium levels through the application of calcium chloride. Because the calcium chloride applications caused vine and fruit damage, though, economically these results could not be justified until a safe rate can be determined.

Also tests of the effects of pre-harvest calcium chelate treatments were conducted in Japan and China on the storage quality of kiwifruit. In these trials the calcium chelate treatment retained flesh firmness, especially at the end of ripening, and played a role both in delaying ripening and slowing fruit softening, which in turn prolonged the shelf life of kiwifruit[6].

Recent Calcium trials in New Zealand

Independent work was conducted last season on a commercially available amino acid chelate. The aim of this study was to determine the effects of pre-harvest calcium treatments on pre-harvest and post-harvest quality of Hayward kiwifruit. The results indicate that pre-harvest treatments of glycine-chelated calcium have aided in increasing fruit calcium levels, as well as possibly improving post-harvest shelf life of fruit.

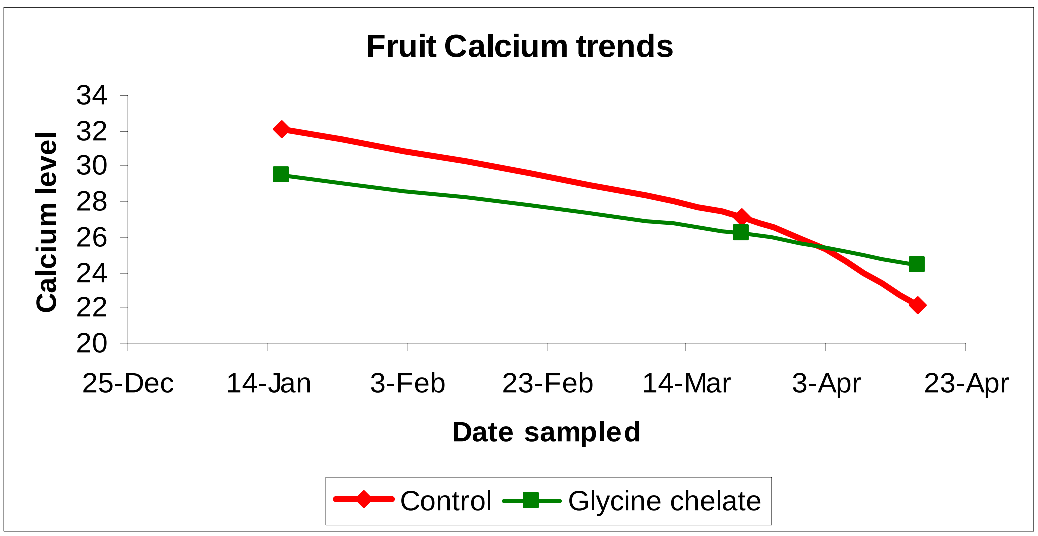
In kiwifruit, as in most fruits, storage quality is related to calcium concentration, and many disorders are associated with low fruit calcium status. This study has shown, like many other studies done previously, that after an early rise, fruit calcium content decreases as calcium influx ceases by the mid-growth stage, whereas volume growth continues until harvest.

The patterns observed in this trial have shown that the chelation technology existing in the formulation of glycine-chelated calcium allows for the calcium ion to bond with two glycine molecules, creating a fully chelated calcium product. The plant recognizes this molecule as a proteinaceous molecule, able to travel in the phloem as well as the xylem. Therefore the calcium can be a mobile element in the glycine-chelated form.

The trial has shown that applications of glycine-chelated calcium can positively increase the calcium content of fruit as opposed to standard practices, which do not include an intensive calcium application regime. The final fruit calcium levels are very important for overall fruit quality as well as post harvest shelf life of fruit. An overall average increase of 15% calcium content in fruit was observed where glycine-chelated calcium was applied. This is quite significant, given that fruit calcium content was the measured parameter, not leaf levels. This increase shows that glycine-chelated calcium is highly systemic, as well as mobile through the fruit cuticle, a characteristic not present in other calcium formulations in the marketplace.

Further to this, the trial indicated a slower dilution of fruit calcium levels, as can be seen in graph 1. The decline was slower, and the addition of foliar glycine chelate seemed to slow the dilution; this resulted in higher harvest levels of fruit calcium than in the control. The trial was conducted on three separate blocks with different paddock history. The same fertiliser inputs were documented over all three blocks, however. Observations also included no phytotoxicity to vines, nor to fruit, meaning that there is a viable alternative to calcium chloride applications for increasing fruit calcium levels.

Fruit is currently in storage, and will be assessed for pitting as well as firmness and overall quality. The trial will be replicated in the 2004/2005 growing season.



Graph 1: Fruit calcium trends over growing season comparing glycine calcium chelate with standard practices.

Summary

New Zealand kiwifruit are sometimes required to be held in storage for up to 9 months. Losses can be significant, primarily due to premature softening of fruit and storage rots. There as been notable underestimation of the importance of calcium in kiwifruit for improved storage of fruit, as well as for reducing fruit softening during the ripening stages. Trials are continuously being conducted with calcium chloride as well as glycine-chelated calcium to assess the contributions these two products may have on the post harvest shelf life of kiwifruit. Calcium chloride has been proven to be phytotoxic when rates exceed 0.5%, whereas recent trials involving glycine-chelated calcium have indicated promising prospects for the kiwifruit industry.

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