Postharvest Fruit Quality and Storage Life in Relation to Mineral Nutrients

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Today's market demands high quality fruit. Mineral levels in the fruit as it grows and after it is harvested are highly significant factors in producing and maintaining fruit quality. Clearly N, Ca, B, Mg and K have the most impact on fruit quality.

"Quality of fruit" means different things to different people. In this article, we view it as the fruit grower does: possessing the properties that yield a profitable price. These include size, color, firmness, and freedom from defects. Of these, size and color will be determined before harvest, and so we are focused primarily on maintaining firmness and freedom from defects after harvest, if we include loss of a "fresh appearance" as a developed defect. It shall be argued that taste should be included, and we will comment on taste where there is relevant information available.

A long list of mineral nutrients are essential for plant growth, but not all of them have been related to postharvest fruit quality. Therefore, we will discuss the effects of only nitrogen, calcium, phosphorus, boron, potassium, and magnesium. Let's look at how these elements are related to the growers' task of delivering quality of apples to the consumer.

Nitrogen (N)

To stimulate growth of young trees, N is commonly applied at high rates. These rates might continue as cropping begins since they can increase yield. But even if they are reduced when trees begin to bear (as they should be), the response to lower rates will probably be slow because reserves of N can accumulate in the tree and the soil during the time of high N fertilization. It is not unusual for harvested fruit, especially from younger trees, to be high in N.

The consequences can be very serious. At harvest high N fruit tend to be larger, greener, softer, more subject to preharvest drop and more likely to be affected with corkspot and/or bitter pit. Following storage, they are more likely to develop scald, bitter pit, brown core, internal browning, and internal breakdown. They are also more likely to develop rots. Furthermore, research has shown that in Red Delicious apples, high N can reduce the development of fruit flavor as they ripen.

Much attention has been given to the form of N being applied. Are some forms less damaging to quality than others? We have conducted many experiments including different N forms, and rarely have we found N form to be a significant factor. We believe that it is the total amount of N being applied during the growing season, not the form or the timing, that influences postharvest quality.

Calcium (Ca)

In 1936 bitter pit in apples was first related to fruit Ca content. Since then, awareness that Ca plays a central role in postharvest fruit performance has become universal. In warmer growing regions bitter pit is generally a big concern, but in cooler regions such as the Northeast we are usually more concerned with more subtle effects of Ca. Ca is one of the cellular regulators of fruit ripening and deterioration: when Ca is low, these processes proceed more rapidly. We see this in the susceptibility of the fruit to many problems. When Ca is low, fruit are likely to ripen earlier and have greater pre-harvest drop, to have more watercore at harvest and to develop more scald, browncore, internal breakdown, internal browning, bitter pit, and rots during and after storage. Of these, only internal breakdown and bitter pit may be direct symptoms of low Ca. The others simply result from the fruit being "older" and less resistant to whatever stresses are producing the symptoms.

Ca is often said to be related to fruit softening, with low Ca levels producing softer fruit. Large increases in fruit Ca definitely increase firmness. However, none of the practical Ca treatments are likely to increase Ca sufficiently to result in firmer fruit. We have nearly 30 years of data on effects of Ca treatments, and significant differences in firmness have been rare. Our opinion is that a Ca treatment might increase firmness slightly, but if so, you've received a bonus benefit. Ca treatments should be applied to reduce the occurrence of storage disorders, not to obtain firmer fruit.

Phosphorus (P)

The significance of P in maintaining fruit quality is hard to assess. In Europe, increased fruit P has often led to longer postharvest life, and periodically there are reports in North America, especially from Canada of benefits from P treatments. However, we have conducted numerous trials with P-containing materials that have raised fruit P, and seldom have they produced any benefit. Others, especially in the Northeast, have had similar results. Thus we believe that, under our conditions, P treatments of established trees are quite unlikely to improve fruit quality.

Boron (B)

B deficiency in apples is a constant threat on most Northeastern soils. Growers should apply B annually unless they have clear evidence that B level is sufficient in their orchard. B deficiency causes corking inside fruit that can lead to

misshapen and cracked fruit. Its effect destroys visual quality of fruit. Growers should be aware however, that excess B treatment can cause earlier ripening, preharvest drop, and poor storage quality. Thus, B treatments need to be made with great care, since either too little or too much can be very harmful.

Potassium (K) and Magnesium (Mg)

K is an important element in fruit quality. Fairly high K levels in fruit are often reported to increase red color and to raise fruit acid level, which can improve fruit taste. We have never worked with K treatments, so have no personal experience to add to what is said in the literature. However, K is a difficult element to manage. It is present in fairly high concentrations in the fruit, so a large crop can deplete a tree's K reserves. In a low-crop year, however, the K in leaves is released to the soil as leaves decay, and is quickly recycled to the tree. Thus, K applications should be done judiciously and be based on annual leaf analyses.

Mg is an element frequently deficient in Northeastern apple orchards, so it is often applied. There appears to be little direct relationship of fruit Mg levels to fruit quality, so applications should be based on tree needs, as shown in leaf analyses

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Interaction of Elements

The above discussion has considered mineral element effects as direct responses. However, there is a great deal of interaction among these elements that greatly influences their effects.

High N probably worsens the effects of deficiencies of all the other elements. The fruit are "weaker" and so more susceptible to other problems. However in the case of Ca, the consequence is clear: high N increases fruit size, and as fruit size increases fruit Ca directly decreases. Anything that increases fruit size will likely decrease fruit Ca and increase storage losses.

K and Mg can directly interfere with the ability of Ca to slow down fruit deterioration. It has often been shown that the ratio of K + Mg : Ca is more closely related to fruit quality than is Ca level alone. This means that if either K or Mg is excessively high in fruits, the impact of low Ca will be increased. This makes it very important that K and Mg only be applied if leaf analysis calls for it, and then only at the rate indicated by the levels in the leaves.

Both P and B also interact with Ca. P apparently works with Ca to maintain quality, so if it is low, Ca is less effective in maintaining quality. B is somehow involved in movement of Ca to fruit on the tree, so if B is low, it can cause fruit Ca deficiency to occur.

Conclusion

Today's market demands high quality fruit. Mineral levels in the fruit as it grows and after it is harvested are highly significant factors in producing fruit that will satisfy this market and maintain financial viability. Clearly, N and Ca demand careful management by fruit growers to achieve high fruit quality. B must be maintained within an adequate range also. Mg and K are important for tree productivity, but fruit quality may be damaged if excessive treatments are applied. P level in fruits does not appear to be related to postharvest quality in Northeastern fruit.

Growers today must produce larger sizes of fruit to satisfy market demand. Larger fruit have lower Ca and are inherently more at risk of quality loss after harvest. Futhermore, the longer fruit is stored before marketing, the physiologically older they become and the more susceptible to disorders they are. A slow market makes it harder to maintain fruit quality.

The challenges don't seem to get easier!

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