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Tree Fruit & Alternative Fruits W. Wash

Completion Report: The Effect of Potassium and Magnesium Applied Fertility on Jonagold Apple Quality

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Introduction

This experiment was initiated because *Jonagold* quality was diminishing in many orchards. The symptoms matched those of a potassium deficiency in several locations, dull green fruit color with insipid taste. *Jonagold* appears to be a high user of both potassium and magnesium, suggested by the fact that adjacent varieties didn't show symptoms as fast. A 40-bin crop of apples takes out 120 lb/A of K_2O with the crop alone. Soil analysis shows that drip irrigation leads to a drop in potassium levels. During dry periods the trees in an orchard become dependent on the wetted area or "onion," underneath the drip emitters to provide both soil moisture and mineral nutrition. At this time the fruit is also sizing rapidly and demand for potassium is particularly high.

An off-station experiment in a plot at the Merritt orchard in Skagit County, begun in 1995, was continued in 1996 and 1997 to evaluate the effect on *Jonagold* apple quality of potassium and magnesium applied granularly in the fall and through fertigation during the growing season. In addition, a second plot was evaluated at WSU-Mount Vernon in 1996, 1997 and 1998. The latter *Jonagold* orchard was in its fifth leaf in 1998. The site at the station had been under the experimental fertility regime for four years, and 1998 was the third year for data collection from that plot.

Date of Initiation and Completion

The project was initiated in the spring of 1995 and completed in the fall of 1998.

Methods

The Merritt plot was set up as a randomized block design consisting of three treatments replicated four times. Each block contains 6 trees, all standard Jonagold. The station experiment was set up as a randomized block design consisting of three treatments replicated eight times. Each block contained 12 trees, 3 trees each of 4 Jonagold strains: DeCoster, King (Jored), Jonagored, and standard Jonagold. The treatments for both locations were as follows:

1. Irrigation with H_2O only.
2. Fertigation with K_2O two times a week.
3. Fertigation with K_2O and Magnesium two times a week.

Treatments 2 and 3 were given 7 lb/A of K_2O per week for 10 weeks (muriate of potash and potassium thiosulfate alternated). The total weekly allocation was divided in half and applied at 3.5 lb K_2O/A twice a week. Treatment 3 also included magnesium (Epsom salts-$MgSO_4$) at 20 lb/A per week for 18 weeks. The magnesium was also divided in half and applied at 10 lb/A twice a week. Prior to harvest, three fruit from each treatment replication at both plots were evaluated for starch, soluble solids, and pressure. Soil, leaf and fruit analyses were done yearly in July, August, September and October at both locations. In 1998 the Merritt plot had been discontinued, so soil analysis of the Mount Vernon plot only was done June 2, 1998, with additional soil, leaf, and fruit analyses done on July 8, August 14, and September 11, 1998.

Treatment plots were amended annually in December with granular soil applications of potassium, magnesium, and boron. Plots received an equivalent of the following nutrients/planted acre banded on a 4' herbicide strip: Treatment 1 plots received no granular amendments; treatment 2 plots received 120 lb K_2O and 2 lb boron; and treatment 3 plots received 120 lb K_2O, 60 lb magnesium, and 2 lb boron.

Results

An analysis of variance for a randomized block design was used to statistically calculate all data. Both locations showed no significant differences between treatments in starch conversion, soluble solids, or fruit pressure.

Both locations had significant differences in soil potassium between the plots where potassium was added (treatments 2 and 3, maintaining or increasing levels) and the control (treatment 1) showing reduced potassium levels. For example, data from the station plot showed that in treatment 1 where soil was left unamended, potassium levels dropped each year, from an initial reading of 286 ppm in 1996, 255 ppm in 1997, to 215 ppm in 1998. At the Merritt commercial orchard plot, levels of soil potassium dropped from 450 ppm in the beginning of the experiment (July 1995) to 250 ppm at the end of 1997 in the drip onion.

Soil sulfur was significantly higher in treatment 3 at both locations for 1995 and 1997; in 1998 at the station plot soil sulfur was significantly higher in treatments 2 and 3. Sulfur was an element in the fertilizer applied to the K + Mg treatment. There was a significant increase of magnesium also in treatment 3. Soil micronutrients zinc, manganese, copper, and iron all increased, particularly in treatment 3, and some of the differences were significant. Boron levels in the soil were significantly lower in treatment 2 than in 1 and 3 at the Merritt location.

Soil pHdecreased with fertigation amendments while salts increased. (Decreased pH may account for the increase in micronutrients noted above.) Soil calcium decreased in plots where potassium and magnesium were added (treatments 2 and 3). Soil phosphorus decreased in treatments 2 and 3 as well, to a significant degree in the station plot, and pH may have affected this also.

Leaf analysis showed no increase in potassium and magnesium, even though soil treatments contained higher levels of those elements in treatments 2 and 3 compared to the control. Leaf micronutrient content trended toward increase at the station plot but toward decrease at the Merritt plot. Leaf calcium was not affected by any treatment, even though soil calcium did show differences.

Resultsof the fruit analysis showed no significant difference between the treatments throughout the duration of the trial. However, the soil test showed a very significant drop in soil potassium from about 350 ppm in the beginning of the experiment (July 1995) to around 200 ppm at the end of 1998 within the area of the drip onion. We anticipate that in a few years a threshold of deficiency may be reached.

Discussion

Levels of soil potassium declined significantly in the unamended soils during the first year of each experiment, and continued to decline in 1997 and 1998. The 1995 soil analysis of the Merritt plot showed potassium levels above 400 ppm, and by 1996, potassium levels had dropped midway between 200-300 ppm. During 1997 and 1998 the levels at the Merritt plot were in the 220-280 ppm range. At the station plot the level of soil potassium in 1996 was 286 ppm, and by 1998 the levels had declined to 215 ppm.

However, higher soil potassium levels were not reflected in the leaf potassium levels during the late season. In both 1995 and 1996 potassium dropped from August to October, and this trend continued in 1997 and 1998. Potash fertigation did not help boost potassium levels. A different method to increase potassium levels may be beneficial, particularly in years when high nitrogen is present in soil.

Fruit color and maturity were noticeably better for 1996 than 1995, and the improvement in color was maintained in 1997 and 1998. Higher than normal release of nitrogen in August of 1995 increased the leaf ratio of nitrogen to potassium to 2:1. This was well above Stiles' suggested 1.25:1 ratio of nitrogen to potassium. In contrast, the 1996 leaf nitrogen to potassium ratio was 1.18:1. Levels in 1997 ranged from 1.28:1 to 1.59:1, with the average at 1.43:1. In 1996, 1997 and 1998, August rainfall was lower, and nitrogen was not released into the soil at the high rate of 1995. While levels were not as low as Stiles' recommended ratio, it was lower compared to 1995 in all plots in 1996 and 1997.

We observed better and earlier color in all treatments of the station plot in 1998. Notable was the leaf nitrogen ratio, which was 1.16:1, below Stiles' suggested 1.25:1 ratio. This was primarily because the nitrogen levels were lower than in 1997 (ranging from 1.28:1 to 1.59:1, average at 1.43:1) and the potassium levels higher. In addition, higher soil boron levels in 1996 and 1997 may also have affected potassium uptake positively as suggested by Stiles, indicating that soil boron levels need to be monitored annually.

Since the data indicatethat the level of potassium drops significantly from mid-July to harvest, an irrigation-fertigation system has been used for watering, but increasing potassium in the leaf tissue by means of fertigation has been difficult. Management of increased nitrogen complicates the situation further, making it difficult to keep the ratio of nitrogen to potassium close to 1.25:1. For example, in 1997 the soil nitrogen levels were lower in the Merritt plot than the WSU-Mount Vernon plot. This lower nitrogen level at Merritt's was also reflected in the leaf. However, this plot also had lower levels of potassium compared to the station plot. As a result, nitrogen to potassium ratios were similar in both plots, with the station plot having a lower overall ratio of 1.41:1, compared to the Merritt plot at 1.46:1. Both plots could benefit if the nitrogen to potassium rate is managed. Trees in the Merritt plot might benefit from increased leaf potassium, and the station plot might have been improved by reducing nitrogen.

Simply adding potassium is not the answer. If the level of potassium in the soil is sufficient (200 ppm or above), then absorbing excess soil nitrogen with grass or turf ground cover may bring about the desired ratio, and lead to improved color. This is particularly important during a wet late summer (August and September) when organic matter in the soil is releasing abundant nitrogen which further delays fruit color. In order to increase the levels of fruit potassium it may be best to apply foliar sprays in the late season, or by using some other method.

We know from observation that a monitored fertility program such as described in this trial has produced improved color and maturity indices for most of the growers using it in western Washington. However, the whole solution is not a simple "cookbook" answer. In some fields with adequate fertility, early season stress can be an adverse factor. Stress can result from a number of causes, such as lack of sufficient water, mite infestation, or anything that adversely influences accumulation of carbohydrates and the overall health of the tree. Stress can also affect early nutrient uptake and the resulting fruit quality. Fruit that looks bad in mid July usually looks bad at harvest. Maintaining good plant health in the early season through regular monitoring, and rarely using additional input of nitrogen, is important. Adopting cultural practices that decrease nitrogen and raise potassium so that the ratio of nitrogen to potassium approaches 1.25:1, and careful monitoring of all nutrient levels, are essential tools in managing orchard nutrition.

In this short-term study, there has been no significant difference in fruit quality, fruit color, or range of harvest indices to differentiate the control plot, which received water only, from the plots that were fertigated. It is an important fact, however, that these plots were established on soils which had been well maintained nutritionally before the trial was initiated and the fruit quality is good in all plots. This indicates that the level of nutrients in the control has not yet dropped below the threshold level for potassium in the soils of these two plots (sandier soils may deplete more quickly). A longer term study might resolve some of the questions raised by this trial. We still need to examine better methods to increase leaf and fruit potassium during the late season that may enhance quality. At present, however, fall application of granular nutrients appears to be the best way to insure that there is a sufficient level of potassium in the soil to keep it above the low threshold level. This restores the nutrients taken out by the previous season's crop, and added fertigation appears not to be necessary.

Recommendations

Based on this trial and on other observations, it is evident that management of the nitrogen-potassium balance for optimum quality in Jonagold orchards is a complex problem. Simply adding potassium is not the answer, particularly in case of a wet late summer when organic matter in the soil is releasing abundant nitrogen. Suggested practices would include the following:

- An annual program of **granular application** of potassium in the early winter has been the most beneficial practice for improving fruit quality.
- **Continued monitoring** of soil elements by soil, leaf, and fruit tests are vital in managing an effective nutrition program, and should be used to check all nutrients that may need to be supplemented annually.
- It is necessary to add back nutrients in the fall to replace what was taken out with the crop. Particular attention should be given to replacing **potassium, magnesium, and boron**. Fertigation in itself has not shown any additional benefit.
- Early season **stress** appears detrimental to attaining high quality in Jonagold. Good plant health in the early season, and limiting any addition of nitrogen, seem to be most important
- Adopting cultural and fertilizing practices that **decrease** nitrogen and **increase** potassium, particularly in the later season, may assist in maintaining a target ratio of nitrogen to potassium at **1.25:1** for improved color and quality.
- Expanding the grass area of the orchard and narrowing the herbicide strip should Increase nitrogen uptake from the soil by the cover crop, thereby reducing the amount of nitrogen available to the trees. Adding potassium in foliar spray may be another possible method of managing the nitrogen/potassium ratio.
- Other watering methods, such as microjets, may **increase the overall wetted area of orchard** and potentially increase potassium uptake due to greater area of root activity.
- Orchards in western Washington have been significantly improved when a monitored fertility program was in place.

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