LEAF AND FRUIT MINERAL CONTENT AND PEEL THICKNESS OF ‘HAMLIN’ ORANGE

KELLY T. MORGAN,¹* ROBERT E. ROUSE,¹ FRITZ M. ROKA,¹
STEPHEN H. FUCH² AND MONGI ZEKRI²
¹University of Florida, IFAS
Southwest Research and Education Center
2686 State Road 29 North
Immokalee, FL 34142-9515
²University of Florida, IFAS
Department of Horticultural Sciences
Citrus Research and Education Center
700 Experiment Station Road
Lake Alfred, FL 33850
³University of Florida, IFAS
Hendry County Extension
P.O. Box 68
Labelle, FL 33975-0068

Additional index words. Citrus sinensis, flatwoods, potassium nutrition

Abstract. There were reports in late December 2004 that the number of split fruit in ‘Hamlin’ oranges [Citrus sinensis (L.) Osbeck] was higher than in previous years. Such reports included several loads, which were mechanically harvested and rejected at the juice plant because of split fruit. There were also reports of rejected trailer loads from hand-picked blocks. Initial visual inspection of the fruit in the affected groves indicated that the peel thickness of ‘Hamlin’ oranges appeared to be thinner than usual. Previous studies have demonstrated positive correlations among fruit size, peel thickness and tree nutrition. Fruit samples from trees on three rootstocks were collected from seven locations in the Immokalee area. Along with fruit size, juice quality, and peel thickness measurements, samples of the juice and dried peel were analyzed for calcium (Ca), phosphorus (P), and potassium (K) for each rootstock and location. There were significant differences in fruit size and peel thickness attributable to location, whereas rootstock had no significant effect on either fruit size or peel thickness. There were no correlations among fruit size, fruit quality, and peel thickness with Ca and P concentrations. However, there was a correlation between fruit size and peel thickness with K concentrations in the juice and fruit peel. Reduced peel thickness due to reduced K nutrition could lead to increased splitting of fruit. Therefore, the use of annual leaf samples to modify K fertilizer practices on a block specific basis should be implemented.

A number of citrus growers in southwest Florida reported that the number of split fruit during harvesting of ‘Hamlin’ oranges in late Dec. 2004 were higher than in past years. Some growers reported that trailer loads of fruit were rejected by processing plants due to the increased incidence of split fruit. In addition, fruit splitting seemed to have been exacerbated by mechanical harvesting. Inspection of the fruit at the affected groves indicated that the peel thickness of ‘Hamlin’ oranges appeared to be visibly thinner than usual. We hypothesized that inadequate tree nutrition played a role in the production of thin peeled fruit.

The K requirement of citrus is often not easily determined because citrus can be grown within a wide range of K without showing visible symptoms on vegetative growth (Koo et al., 1984). The need for additional K to overcome deficiencies may be more widespread than is generally believed because more K is removed by citrus fruit than any other nutrient. About 4.2 lb of K are removed for every ton of fruit harvested (Chapman, 1968; Smith and Reuther, 1953). A good-producing orchard may lose in excess of 100-150 lb/acre of K per year in the harvested fruit. The use of leaf analysis as a diagnostic tool for nutrient requirements in citrus has been developed (Chapman, 1968; Smith, 1966b) and used as a guide in planning fertilizer programs. The use of leaf K concentration to evaluate the nutritional status of K in citrus is especially useful because visible leaf symptoms of K deficiency do not appear until the trees are extremely deficient.

The benefits of increased K content on citrus fruit quality include increased fruit size and improved rind thickness (Cohen, 1976). However, excessive K content may result in greater rind coarseness, decreased juice quantity, increased juice acidity and reduced Brix/acid ratio. There was no effect of K on tree size except in K-deficient trees with leaf concentrations <0.7% (Deszyck et al., 1958; Reese and Koo, 1975). Koo and Reese (1977) found the influence of K on ‘pineapple’ orange yield and quality to be due, in part, to the high rate of premature fruit drop combined with small fruit size. Low K will reduce fruit production by producing small size fruit, promoting fruit splitting (Bar-Akiva, 1975) and increasing pre-harvest fruit drop (Calvert, 1969; Chapman, 1982; Koo, 1979).

Problems associated with citrus fruit rind splitting have not been a common occurrence in hand harvested groves routinely fertilized with K. Mechanical harvesting, however, subjects the fruit to harsher handling treatment. These fruit can fall from heights of more than 15 ft onto hard catch frame surfaces. Consequently, thin-peeled fruit can be damaged by the rigors of mechanical harvesting. Citrus nutritional recommendations may have to be altered to minimize the occurrence of thin peels in mechanically harvested fruit. The objectives of this study were to 1) determine if a relationship exists between peel thickness and rootstock, 2) confirm the relationship between leaf and fruit peel mineral concentration, and 3) determine the relationship of leaf mineral content and fruit peel thickness. These relationships will lead to future work on establishing minimum fruit peel thickness required for mechanical harvesting.

Materials and Methods

Random samples of 20 ‘Hamlin’ orange fruit were collected in Jan. 2005 from seven citrus orchards in Collier or Hendry counties, near Immokalee, for the purpose of determining the effect of soil nutrition on citrus fruit peel thickness. Six of the seven sites were commercial orchards; the seventh site was an experimental grove at the University of Florida/IFAS Southwest Florida Research and Education Center. Separate samples of mature ‘Hamlin’ orange fruit were collected from trees grown on two or more rootstocks at each orchard. Fruit samples from trees grown on Swingle citrumelo (C. paradisi Macf.
× *Poncirus trifoliata* (L.) Raf.] and Carrizo citrange (*C. sinensis* L. Osbeck × *P. trifoliata* L. Raf.) rootstocks were collected at each site. Samples were collected from trees grown on Cleopatra mandarin (*C. reticulata* Blanco) at three of the seven sites for a total of 17 orchard blocks. Fruit size was determined by weighing each fruit and measuring diameters between the stem end to bloom end and across the equatorial plane. Rind thickness of each fruit was determined at two locations after cutting along the equatorial plane. Juice was extracted from each 20 fruit sample and combined. Juice volume, Brix, and acid were measured and the Brix/acid ratio calculated for each sample. Wedges of peel tissue were collected from each fruit and combined. The peel tissue was dried at 160°F for a period of one week and ground to a powder using a roller ball mill. The ground tissue was analyzed for N, P, K, and Ca. Leaf mineral concentration data for samples collected in July or August of 2004 were available for 7 of the 17 blocks used in the study. Fertilizer records for 2004 were collected for all 17 blocks.

Leaf and peel mineral content, juice quality, and peel thickness data were separated by rootstock and analyzed by ANOVA using the Mixed Procedure in SAS (SAS, Corp., Cary N.C.). Fruit size, quality, and peel thickness data were analyzed by regression analysis and significance of correlation coefficients (*r*, *P* < 0.1) are reported.

**Results and Discussion**

Fruit weight, fruit size, and peel thickness varied within the relatively narrow ranges of 0.26-0.53 lb, 2.4-2.9 inches, and 0.12-0.17 inch, respectively. Fruit samples from three rootstocks were analyzed to determine the interaction of rootstock on fruit quality. None of the external fruit quality parameters (fruit weight, fruit size, or peel thickness) were significantly different (*P* = 0.1) among the three rootstocks sampled. Likewise, juice quality, and peel nutrient concentrations were not significantly correlated with rootstock.

No correlations were found between peel thickness and the N, P, or Ca concentrations in leaf or peel. Fruit size, and juice quality were not correlated with N, P, or Ca leaf or peel concentrations. However, there were several positive correlations between fruit and juice quality parameters and K concentration.

Increased fruit production from K fertilization has been reported with leaf K concentrations of up to 1.5-1.7% in Florida (Chapman, 1982; Koo, 1979). The need for maintaining K levels within the optimum range is probably more critical for enhancing external fruit quality than other aspects of citrus production. Peel thickness was directly proportional to K concentration in leaf (Fig. 1) and peel (Fig. 2) tissues with correlation coefficients of 0.704 (*P* = 0.06) and 0.898 (*P* = 0.03), respectively. Fruit from trees with leaf K concentrations in the optimum range of 1.2-1.7% resulted in fruit peel thicknesses of 0.15-0.17 inches. Fruit rind K concentrations were 0.6-1.2% over the same range of peel thickness.

Leaf and peel concentration did not have as great an effect on fruit size as peel thickness. Fruit diameter increased from 2.6 to 2.9 inches from groves with leaf concentrations within the optimum range of 1.2-1.7%. Reese and Koo (1975) reported that above-optimum K levels in trees will result in large individual fruit with coarse, thick rinds and higher numbers of green fruit at harvest, whereas, low K will produce small fruit. Fruit peel thickness was proportional (*r* = 0.792; *P* = 0.06) to fruit size regardless of K concentration (Fig. 3).

Potassium effects on juice characteristics were small, and were related to the inherent differences in fruit size. Larger fruit had higher juice, lower soluble solids, and acid content than small fruit. Consequently, K effects on juice characteristics, if any, were indirect rather than direct. Potassium has been reported to have only minor influence on soluble solids content, but the soluble solids/acid ratio was consistently reduced by increased K level because of the positive relationship between juice acidity and K (Koo and Reese, 1977; Smith, 1966a).

Peel K concentrations of 0.3-0.9% correspond (*r* = 0.876; *P* = 0.03) to a range of 0.65-1.6% leaf K concentration (Fig. 4). However, annual fertilizer K application rates reported by block managers, ranged from 210 to 280 lb/acre and did not correlate with either leaf or peel K concentrations. This could

Fig. 1. Linear relationship (*r* = 0.704; *P* < 0.06) between leaf potassium concentration and fruit peel thickness for 'Hamlin' orange samples from three blocks on 2 or 3 rootstocks each in the Immokalee, Florida area with spring flush leaf sample analyses. Each point represents the mean fruit peel thickness for a single sample (n = 20 fruit) from the 7 orchard blocks from which leaf samples were taken in July or August 2004.

Fig. 2. Significant positive relationship (*r* = 0.898; *P* < 0.03) between fruit peel potassium concentration and mean fruit peel thickness for 'Hamlin' orange samples (n = 20 fruit) from trees grown on multiple rootstocks from seven selected orchards in the Immokalee, Florida area. All orchards and rootstocks were combined for a total of 17 samples.
be indicative of 1) reduced K uptake efficiency at application rates greater than 200 lb/acre, 2) competition between leaf and peel tissue for available K at high fruit production, or 3) reduced soil K availability due to leaching. Since most of the samples in this study were within the optimum range of leaf K concentration, reduced uptake efficiency seems to be the most plausible answer. However, it can not be ruled out that yield and the unusually wet tropical weather associated with hurricanes in late summer 2004 may have contributed to the lack of correlations between K rates and tissue concentrations.

Conclusion

Concern was raised by citrus growers that fruit splitting associated with mechanical harvesting could reduce potential returns. As in previous studies, it was demonstrated that K nutrition greatly influenced fruit size and peel thickness. Reduced peel thickness due to reduced K nutrition could lead to increased splitting of fruit. Therefore, the use of annual leaf samples to modify K fertilizer practices on a block specific basis should be implemented. More work needs to be done to determine if low K rates increase fruit splitting and to establish minimum fruit peel thickness required for mechanical harvesting. Citrus nutritional recommendations may need to be modified to prevent fruit splitting in mechanically harvested fruit.

Literature Cited


Fig. 3. Significant positive relationship (r = 0.732; P < 0.05) between mean fruit peel thickness and mean fruit diameter for 'Hamlin' orange samples (n = 20 fruit) from trees grown on 2 or 3 rootstocks from seven selected groves in the Immokalee, Florida area. All groves and rootstocks were combined for a total of 17 samples.

Fig. 4. Significant positive relationship (r = 0.876; P = 0.05) between fruit peel potassium concentrations and leaf potassium concentrations for 'Hamlin' orange samples (n = 20 fruit) from three groves with 2 or 3 rootstocks each in the Immokalee, Florida area for a total of 7 samples.