Seasonal changes in leaf nutrient concentration of male and female hardy kiwifruit grown in Oregon

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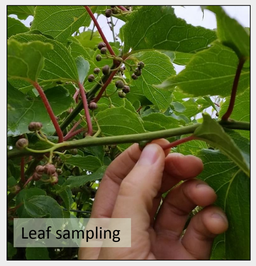
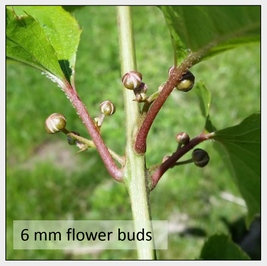

Leaf sampling


6 mm flower buds

Full bloom

Male summer pruning

Green fruit 15-18 mm

Female vine in summer

Introduction

Hardy kiwifruit (*Actinidia arguta* var. *arguta)* are grown commercially for fresh market sales in Oregon and for overseas markets. 'Ananasnaya' is the most widely grown cultivar worldwide (Strik and Hummer, 2006). Production methods for hardy kiwifruit largely follow successful practices of the more widely grown "fuzzy" kiwifruit (*Actinidia chinensis* var. *deliciosa*), including fertilization and nutrient management (Himelrick and Powell, 1998; Strik, 2005). Fertilization recommendations are based on the requirements of female vines despite differences in management of male vines, especially summer pruning as compared to winter or dormant pruning. Nutrient sufficiency standards for fuzzy kiwifruit have been recommended by Clark et al. (New Zealand, 1986), Cresswell (Australia, 1989), and Velemis et al. (Greece, 1995). However, it is unknown whether these standards can be applied to hardy kiwifruit while maintaining fruit production and quality at a commercially acceptable level. Existing nutrient sampling recommendations also lack sufficient detail or are contradictory for which leaves should be sampled and at what time of the season.

Objectives

- Optimize sampling time and method for hardy kiwifruit grown in Oregon by:
  - Determining if sampling should be done by phenological stage or calendar date
  - Determining if males and females, or different shoot types, should be sampled separately

Methods

The study was conducted in 2008 and 2009 in mature kiwifruit vines (planted in 1990) at OSU's North Willamette Research and Extension Center. Female ('Ananasnaya') and male vines were arranged in a completely randomized design with three one-plant replicates. Vines were trained to a T-bar trellis, drip irrigated, with weed-free in-row strips and a perennial grass cover crop between rows. Plants were fertilized in a split application for a total of 79 $kg \cdot ha^{-1}$ N each year. Males received an extra 22 $kg \cdot ha^{-1}$ of N in 2009. Females were pruned during the dormant season and males were pruned shortly after bloom. Leaves were sampled biweekly from determinate and indeterminate shoots of male and female plants, starting when female flower buds were 6 mm in diameter and continuing through fruit harvest. Most recent fully expanded leaves were sampled from indeterminate shoots while leaves in the 1st through 4th node positions past the fruiting zone were sampled from determinate shoots. Approximately six leaves were collected per plant and shoot type, and samples were analyzed for macro- and micronutrients. Data were analyzed using a split-split plot design with PROC MIXED (SAS version 9.3) and PROC UNIVARIATE (to assess normality of data).

Results & Discussion

Year effect:

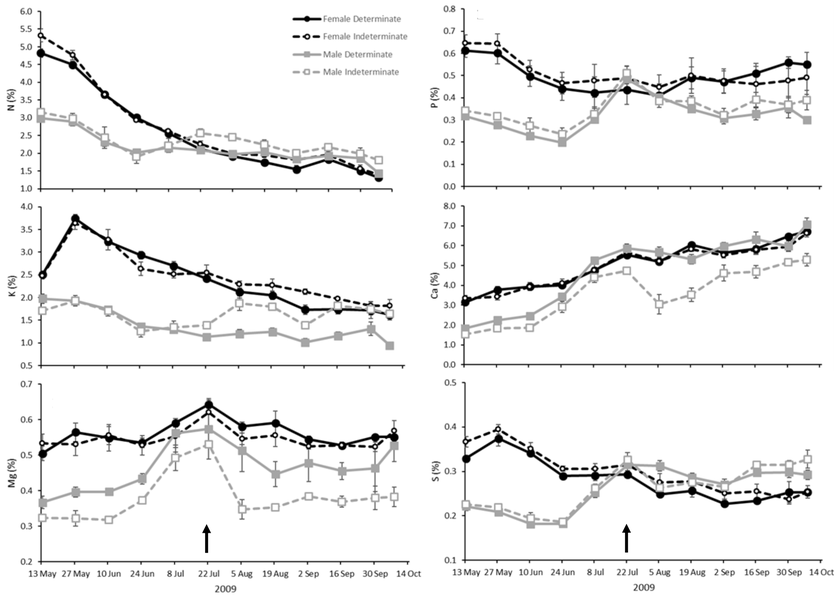
- Plant growth stages were reached 2 to 3 weeks earlier in 2009 than 2008, but nutrient patterns did not always shift to reflect this
- Patterns of change in N, Ca, Mg, B, Fe, Mn, and Zn concentration were seen at similar calendar dates in both years
- Leaf concentrations of most nutrients were lower in 2009 than 2008

Plant gender:

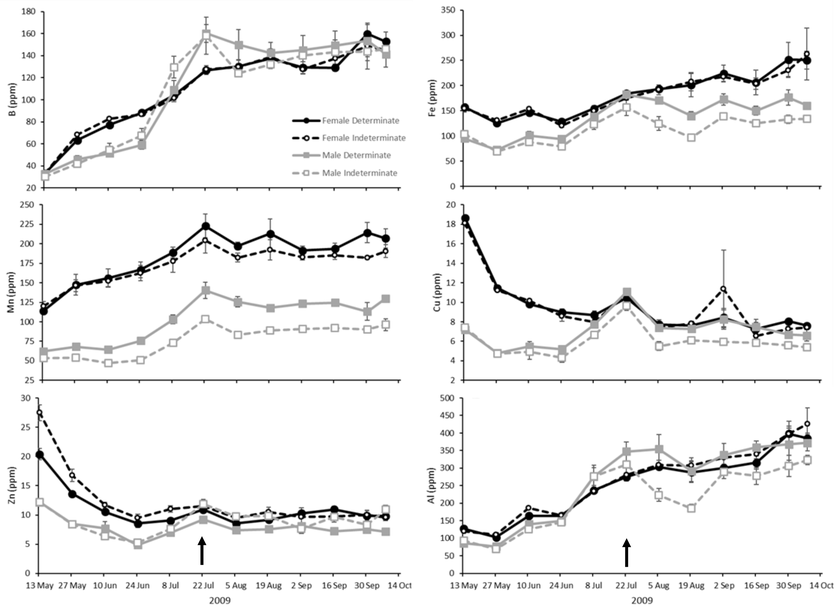
- Female and male vines had significantly different leaf concentrations of most nutrients for some or all of the season (Figures 1 & 2)
- Leaf nutrient concentrations were generally higher in female than male vines, especially early in the season

Shoot type:

- Large differences in leaf nutrient concentration of determinate and indeterminate shoots occurred only in male vines, particularly after summer pruning (shown with arrows below)



Figures 1 & 2: Macronutrient (above) and micronutrient (below) concentrations (± SE) of *A. arguta* from 6 mm flower bud diameter to 50-75% red fruit in 2009. Arrows indicate the date that male vines were pruned



Ripe fruit

Leaf sampling time:

- Since we found male and female vines need to be sampled separately, and female vine nutrition is of primary interest, we analyzed for optimum sampling time for females only
- Mid- to late August was the most stable time for sampling for most nutrients, except N and Mg. There was no stable time to sample N, while Mg was stable later in September.
- Sampling in mid- to late-August resulted in little effect of shoot type in female vines; growers could thus sample any shoot on female vines and have consistent analysis results

Comparison to fuzzy kiwifruit standards (Clark et al., 1986):

- Hardy kiwifruit in our study followed similar patterns as those reported for fuzzy kiwifruit, but concentrations were different
- Leaf K and S were within sufficiency ranges, while N and Cu were either within or slightly below the standards
- Leaf P, Ca, Mg, Fe and Mn concentrations were above the standards, and leaf B would be considered excessive
- Leaf Zn was in the deficiency range despite no visible plant symptoms. No standards exist for leaf Al
- Our leaf nutrient concentrations were more similar to those reported for hardy kiwifruit in Belgium (Decorte et al., 2015); however, the many differences found between our studies may be due to cultivar or other factors

Summary of Recommendations

- The most stable period of time for most nutrients was mid- to late August. This is when leaves should be sampled
- Female vines must be sampled separately from male vines
- Leaves sampled from determinate and indeterminate shoots can be combined if tissue sampling during the recommended window of time
- Tissue standards for hardy kiwifruit should be developed due to large differences between hardy and fuzzy kiwifruit

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