Effects of exogenous bioregulators on fruit and essential oil yield of organic Persian lime
(*Citrus latifolia* Tanaka)

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**Introduction**

Limes are grown mainly for the fruit juice and valuable essential oils synthesized in the fruit flavedo. As with many agricultural products, markets for organic citrus juice and essential oils are on the rise. A problem in Tahiti lime production is its high fruit abscission rate, over 90% (Flores-Torres et al., 2010). Treatments with traditional synthetic bioregulators may lower citrus fruit abscission rates while increasing juice and essential oil content (Ladaniya, 2007).

Several studies have been published about using gibberellins (GA) and auxin separately or combined as pre-harvest treatments to enhance fruit quality. The effects of other plant bioregulators on citrus seem to have been eclipsed by the reliable outcomes of GA and auxin applications (Guardiola, 2000). Moreover, most of the PGR pre-harvest experiments for fruit yield and quality improvement have been done with orange cultivars (*C. sinensis* Osbeck), and relatively little work has been done with limes, which are grown in slightly warmer climates than oranges. Tahiti lime produces parthenocarpic fruits, which may drastically change the physiological aspects of fruit set and necessitates its own PGR research.

A variety of growth regulating substances is available that might be used as pre-harvest enhancers of fruit quality, but their effects need further evaluation. However, little has been reported on the effects of bioregulators approved for organic production on the yield and essential oil of citrus in general and lime in particular.

Near Infrared Spectroscopy (NIRS) can be used as a non-destructive, real time analysis method to evaluate the terpene content in the essential oils in citrus fruits. The C-H stretch bands have confirmed the presence of terpenes in Tahiti lime flavedos analyzed directly without solvent extractions (Díaz-Candelas et al. unpublished). The purpose of this study is to evaluate the effect of different growth regulators on yield and quality of Persian lime fruit and the essential oil composition by NIRS.

**Materials and Methods**

The field research was conducted during October 2011-February 2012, using a 6-year old organically-managed Persian lime orchard in the Agricultural Experimental Station in Lajas. Post-harvest life and terpene analyses were conducted at the Fruit Crops Laboratory and the NIR Chemistry Laboratory of the University of Puerto Rico in Mayaguez, respectively.

All the bioregulators (except AVG) were first applied early in the fruit development phase (fruits <10 mm in diameter). The bioregulators evaluated were (1) aminoethoxyvinylglycine (AVG, 302 mg per tree applied once, four weeks before harvest); (2) a commercial extract of *Ascophyllum nodosum* (AN, 0.6 mg kinetin equivalent per tree, applied every three weeks), (3) a commercial blend of B vitamins, triacontanol, and brassinolide (TB, 0.04 mg a.i. per tree, applied every three weeks), (4) gibberellic acid 3 (GA₃, 12 mg a.i. per tree applied twice, at the start of fruiting and 2 weeks later), (5) gibberellic acid 4/7 (GA₄/₇, five weekly 0.672 mg applications per tree starting at fruiting), (6) GA₃ and GA₄/₇, applied separately to the same tree at the rates and times described...
above, and (7) a blend of amino acids from hydrolyzed shark tissues (AHS, five bi-weekly applications of 3.4 mg a.i. each).

Leaf chlorophyll concentration was determined every 14 days using a SPAD meter. Flowers produced after the first application of bioregulators were counted every 2 weeks. Fruit retention was determined as compared to control plants, and fruit number and weight were evaluated at harvest. Fruits were harvested at the mature stage from December 2011 through February 2012. Within 24 hours after fruit harvesting, whole fruits were non-destructively analyzed using near-infrared spectroscopy (NIRS) to assess fruit essential oil content and quality in the fruit peel. After NIRS analysis, we determined percentage of fruit juice per weight, as well as juice acidity and soluble sugar content.

**Results and Discussion**

Leaf chlorophyll values tended to be lower in trees treated with AVG, GA₃, GA₄/₇, and GA₃+GA₄/₇ as compared to other treatments (data not shown). The number of flowers produced and retained significantly increased in trees treated with AN, AHS and AVG as compared to check trees (Figure 1).

AVG treatments had the highest flower and fruit yield and quality during a period of time (49-71 days after initiation of treatments), but flower and fruit abscission rate augmented afterwards (Figures 1 and 2). The AVG treatment resulted in the highest juice percentage, followed by GA₄/₇, and GA₃+GA₄/₇. After four weeks of storage, AVG fruits had the highest juice percentage, followed by AN and GA ₄/₇ (Figure 4).

NIRS results suggest a positive correlation between fruit size and terpene content in the flavedo essential oils. The NIRS technique can differentiate between different tissues and fruit sizes. Further calibrations should be developed to refine the technique towards distinguishing the effects of bioregulator treatments on essential oil composition.

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Figure 1. Effect of bioregulator application on flower increase and retention over time after first application. All but AVG were applied just after petal drop and early fruit development from days 1 to 80 according to their respective recommendations. AVG was applied on day 63, four weeks before first harvest. Quantity presented as % of the highest yielding treatment.

Figure 2. Effect of bioregulator application on fruit retention over time. All but AVG were applied just after petal drop and early fruit development from days 1 to 80 according to their respective recommendations. AVG was applied on day 63, four weeks before first harvest. Quantity presented as % of the highest yielding treatment.
Figure 3. Effect of pre-harvest bioregulator application on stored fruit juice content (fruit juice weight as a % of its respective fruit weight).

References:


