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A Measurement System for Quantifying Citrus Foliage Volume and Porosity

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Abstract: Accurately quantifying the variation of citrus canopy foliage parameters in an orchard has several important applications in precision management of citrus production. The major foliage parameters are considered as tree height, volume, mass, percent surface production area, and porosity. The goal of this study was to develop a measurement system that can accurately measure these parameters, particularly tree porosity and volume. A laser measurement system was developed on a small utility vehicle platform. The measurement system consisted of a laser scanner, a LabVIEW program for controlling the laser scanner, an algorithm for obtaining tree canopy volume and foliage porosity from measurements of the laser scanner, and a computer. Field and laboratory experiments were conducted to evaluate the accuracy of the system. Also, different mathematical approaches were utilized to find the relationship between the output of the laser sensor and tree density. Since it is difficult to measure true volume of the tree canopy, the performance of the system for measurement of volume, height, and width was tested on an object of known volume, height, and width. The volume of the object was calculated by summing up the area of individual slice images obtained by the laser sensor. The slice images clearly describe the surface shape of the object at each slice. The error in volume measurement was less than 1%, and the error in height and width measurement was less than 12 cm. To build a calibration equation for measurement of tree foliage porosity, three porous plates with porosities of 39.97, 47.95, and 59.96 %, were made out of paper. The distance data sets were processed using the Fourier transform and then the amplitude spectral densities were used as the porosity index. The R^2 value of the calibration equation between the porosities and measured indices was 0.987. Test results showed the promising potential of the laser scanner for measurement and mapping of tree foliage parameters in citrus orchards.
Key words: Tree canopy, laser sensor, citrus, precision agriculture

INTRODUCTION and LITERATURE REVIEW

The rapidly changing and very competitive agricultural market requires new and innovative farming strategies. Advances in technology can be applied to maximize crop profitability by optimizing the application of crop inputs, maximizing yield, and reducing the management risk factors and pollution associated with agriculture. Information-based management technology is a new concept in agriculture which is playing an increasingly important role in today's agricultural production systems, regardless of operation size or commodity type.

An information-based pest and disease management technique depends heavily on reliable and cost-effective site-specific data collection. The lack of sensors and instrumentation that can rapidly determine plant and soil characteristics in the field is a major bottleneck in the implementation of this technique.

In a citrus production system, yield variation is mainly influenced by disease, pests, weeds, soil fertility, soil moisture, variation in canopy size, and weather. Knowing plant volume and biomass at different stages of crop growth could provide valuable information on the health and needs of a crop. Plant biomass variation can cause variation in yield; therefore, knowing the crop status early in the growing season could give farmers a chance to correct the probable yield-limiting causes.

Ehsani and Lang (2002) built a laser-based system for plant volume measurement. It was able to measure plant volume and height accurately, indicating the possibility to measure the biomass and calculate the leaf area index. Tumbo (2002) et al.

Figure 7 shows the the volume variability map of a citrus orchard mesured by the system developed in this study.

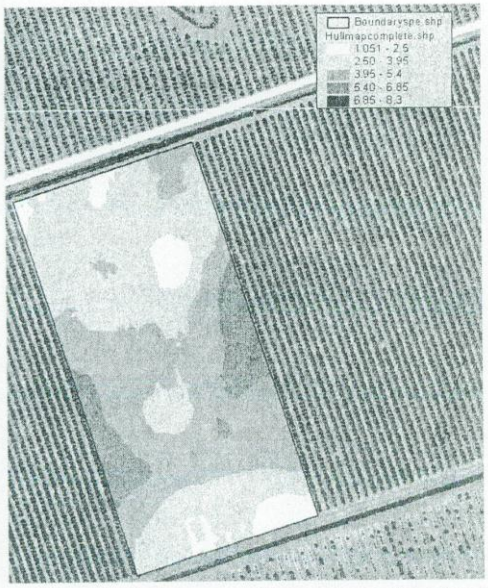

Figure 7. Contour map of tree volume (in cubic meters) in a citrus orchard at Fort Basinger, FL

CONCLUSIONS

A laser-based system for tree canopy height, width, and volume measurements was developed and tested on an object of known volume, height, and width. orchard. The error in volume measurement was less than 1%, and the error in height and width measurement was less than 12 cm. To build a calibration equation for measurement of tree foliage porosity, three porous plates with porosities of 39.97, 47.95, and 59.96 % were made out of paper. Test results showed the promising potential of the laser scanner for measurement and mapping of tree foliage parameters in citrus orchards. The field tests showed the system can accurately measure and map the canopy variability in the field.

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