Precision fruit spraying: measuring canopy density and volume for air and liquid control

T. Palleja Cabre, A. Landers

Cornell University, NYSAES, Geneva, NY 14456, USA.

Introduction

Precision spraying allows fruit growers to apply pesticides only to the target canopy or fruit; to apply the correct quantity according to canopy volume, density, growth stage; and to apply products in an economic and environmentally sound manner. At Cornell University we have conducted research into methods of adjusting both liquid spray and the airflow according to the dimensions of the crop canopy. In both cases this adjustment was made using information provided by a multiple array of ultrasonic sensors that scans canopy vegetation.

Unfortunately, most traditional axial fan sprayers used in fruit canopy spraying create too much air volume and speed, particularly whilst spraying in early to mid-season when the canopy is still developing and is sparse. The result of excess air is spray drift, resulting in environmental pollution to water courses, neighboring properties and damage to susceptible crops. Spray drift means that pesticide is not going onto the target crop resulting in economic waste. Excess air speed also reduces the amount of spray landing on the target fruit due to aerodynamic effects.

Measuring canopy volume

Vegetation detection, based on an array of ultrasonic sensors, was developed and tested by Llorens et al (2013). An array of 6 sensors for orchard characterization and three sensors for vineyard characterization, were mounted on a vertical mast, situated at the front of the canopy sprayer. The distance between the sensors is 50 cm for orchard characterization, to ensure we don't have signal interference between the sensors. With this configuration the system can detect 3 m of height of vegetation in the case of the orchard sprayer.

The sensors send signals to a control board that in turn selects the correct number of nozzleblocks/manifolds, Llorens and Landers (2014). The Lechler Vario Select nozzles can then emit spray according to the canopy. The same sensors/controller is also able to position the actuator and then control the position of the louvre, thus adjusting airflow according to crop volume.

The system we developed measures canopy volume based upon distance between the sensors and the edge of the canopy. If the rows are perfectly straight, the main practical challenge is keeping the tractor in a straight line to ensure accurate readings and distances.

Measuring canopy density

Using the same ultrasonic sensors and control board system described above we have developed an improved sensing method which will measure canopy density as the sprayer moves down the row, irrespective of accurate steering. Field trials were conducted in the 2014 growing season in both apple trees and grapevines.

Results

Figures 1-3 show the effect of canopy growth over the growing season, the reflected sound (presenting itself as voltage) increasing as the canopy density increases. This demonstrates that the sensors were detecting changes in canopy density from sparse canopy in early season to dense in later season. Whilst the hailstorm of 30th July was devastating for fruit quality, the sensor system detected the shredded leaves and the more open canopy, and this is clearly demonstrated in the reduced voltage received.

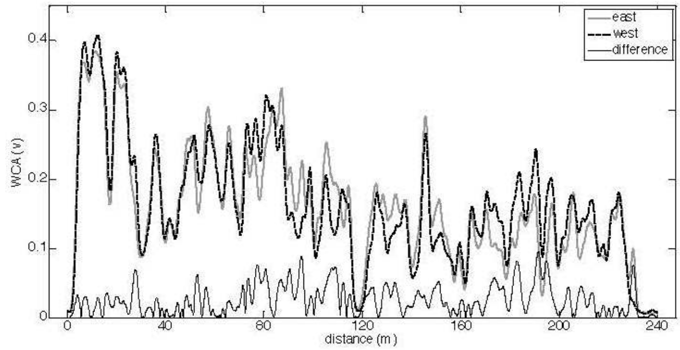

Figure 1: Comparison of the signal (volts) from 6 sensors for each side of the row of trees

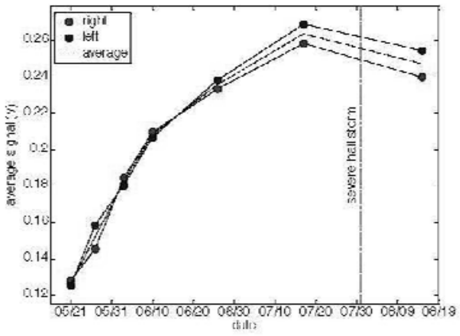

Figure 2: Signal from left and right side of the tree row through the growing season

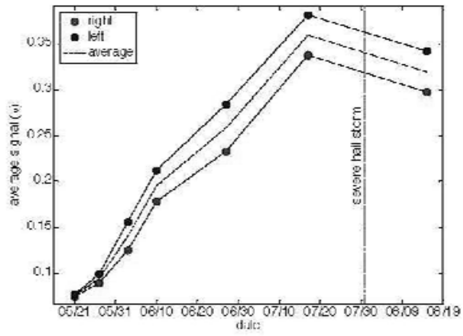

Figure 3: Signal from left and right side of the vine row through the growing season

Further research work will be conducted to relate sensor signal strength to actual canopy measurements using the point quadrat method.

Conclusions

1. The simple ultrasonic sensors detected changes in canopy development over the growing season.
2. The voltage received indicated changes in canopy density.
3. The sensitivity of the sensors is such that it detected the effect of the hailstorm on the canopy
4. The results are very encouraging and indicate that inexpensive sensors can be used to determine canopy density.

Acknowledgements

This project is funded by the support of the NY Apple Research and Development Board (ARDP), NY Wine and Grape Foundation and Lake Erie Grape Growers. We would also like to thank Lechler USA and Durand Wayland for providing the nozzles and sprayer.

References

Llorens, J., Landers, A. and Larzelere, W. (2013). Digital measurement and actuators for improving spray applications in tree and vine crops. Proc. 9th European Conference on Precision Agriculture. July 7-11 2013. Lleida, Catalonia, Spain

Llorens, J. and Landers, A.J. (2014) Variable rate spraying: digital canopy measurement for air and liquid electronic control. In: Aspects of Applied Biology 114. International advances in pesticide application. Pp 1-8