Efficacious insect and disease control with laser-guided air-assisted sprayer

H. Zhu[1], R. Rosetta[2], M. Reding[1], R. Zondag[3], C. Ranger[1], L. Canas[3], A. Fulcher[4], C. Krause[1], Y. Shen[1,5], H. Liu[1,5], Y. Chen[1,3], E. Ozkan[3], R. Derksen[1], J. Locke[1], S. Ernst[3]

[1]USDA-ARS Application Technology Research Unit;
[2]Oregon State University;
[3]The Ohio State University;
[4]University of Tennessee;
[5]Jiangsu University. Email: Heping.Zhu@ars.usda.gov

Current application technology for floral, nursery, and tree fruit crops requires excessive amounts of sprays to control pests due to a great diversity in canopy structure and leaf density. Critical innovative technology is needed to increase application efficiency and reduce uncertainties for conventional pesticide sprayers to achieve real cost benefits with new pesticide application strategies for these specialty crop producers, consumers and the environment.

An automated variable-rate, air-assisted precision sprayer was developed to minimize human involvement in spray applications (Chen et al., 2012; Liu et al., 2014). The automatically-processed spraying system (fig. 1) is able to characterize the presence, size, shape, and foliage density of target trees and accommodate sprayer travel speed to apply appropriate variable amounts of pesticides based on tree canopy needs in real time. It integrates a high-speed, 270° radial and 30-m range laser scanning sensor in conjunction with a non-contact Doppler radar travel speed sensor, a sophisticated automatic nozzle flow rate controller, an embedded computer, a touch screen, a manual switch box, and 40 pulse-width-modulated variable-rate nozzles on a multi-port air-assisted delivery system.

Automatically-controlled spray capabilities to the sprayer are achieved by the sensors and the embedded computer. The laser scanning sensor, which is mounted between the tractor and sprayer, detects the return distance signals of the bilateral tree structure. An algorithm, written in C++ language, translates these signals along with the sprayer travel speed into tree surface structures and determines the amount of sprays for each nozzle. All 40 nozzles on two sides of the sprayer can independently discharge variable flow rates to their designated canopy sections. The embedded computer, touch screen and switch box operational components are mounted in the tractor cab. The functional touch screen displays the sprayer travel speed, total discharged spray volume, spray width, and active nozzles. The operators can also modify spray parameters through the touch screen as needed.

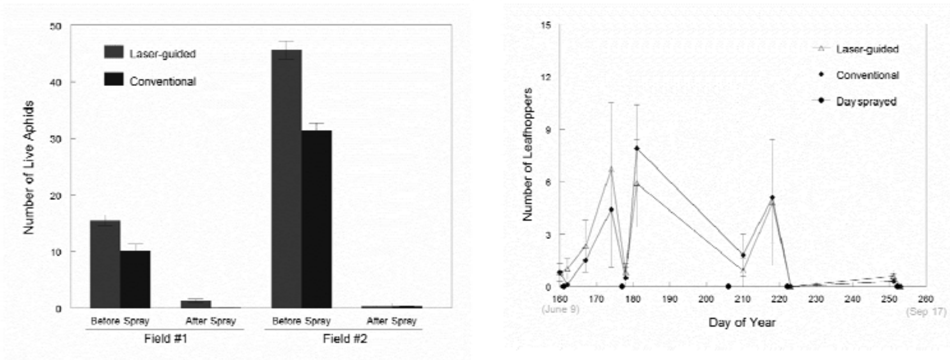
Efficacy of the newly developed variable-rate air-assisted sprayer was investigated for the control of arthropod pests and plant diseases in five commercial nursery fields in three states in 2013 and 2014. Pest control efficiency of the new sprayer was also compared with two conventional air-assisted tower sprayers and three radial air-blast sprayers. Target pests and diseases included aphids, potato leaf hoppers, pod gall midge, sawflies, pear rust, apple scab and powdery mildew on various host plants.

The two-year field biological control tests demonstrated that the laser-guided variable-rate sprayer had comparable insect control efficiencies and comparable or lower disease infection rates than the conventional air-assisted sprayers (figs. 2 and 3). For example, survival rates of aphids on crabapples (fig. 2a) and potato leafhoppers on red maples (fig. 2b) were nearly zero after insecticides were applied with the laser-guided sprayer and conventional tower air-assisted sprayer treatments. There was no significant difference in presence of rusts on 3-year old flowering pears between the laser-guided and conventional radial air-blast sprayer treatments (fig. 3a).

However, there were lower powdery mildew infections on Norway maple trees with the laser-guided sprayer treatment than that with the conventional radial air-blast sprayer treatment (Fig. 3b). This was because the laser-guided sprayer produced the spray deposition distribution across the tree height with lower variations than the conventional sprayer with radial spray patterns.

Figure 1. Newly developed automated variable-rate, air-assisted precision sprayer

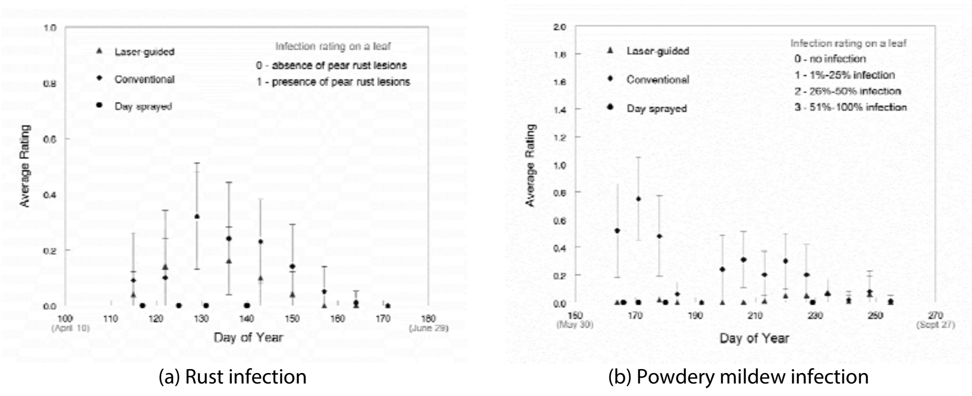
With the comparable insect control efficiency and better disease controls or prevention, the average application rates during two growing seasons with the laser-guided sprayer were 412 L ha^{-1} in field #1, 206 L ha^{-1} in field #2, 309 L ha^{-1}in field #3, 174 L ha^{-1} in field #4, and 201 L ha^{-1} in field #5while the average application rates from the conventional constant-rate sprayers in these five fields were 767, 514, 973, 377, and 478 L ha^{-1}, respectively. Moreover, the laser-guided sprayer reduced pesticide use by 46% to 68%. Thus, the new sprayer was able to drastically decrease pesticide usage thus reducing environmental impact and enhancing applicator safety.



(a) Aphid infestation

(b) Leafhopper infestation

Figure 2. Comparisons of (a) aphid infestations on a crabapple and (b) potato leafhopper infestation on a red maple between the laser-guided and conventional tower air-blast sprayer treatments.



(a) Rust infection

(b) Powdery mildew infection

Figure 3: Comparisons of (a) rust infections on flowering pears and (b) powdery mildew infections on Norway maple trees between the laser-guided and conventional radial air-blast sprayer treatments.

References

Chen, Y., Zhu, H., & Ozkan, H. E. (2012). Development of a variable-rate sprayer with laser scanning sensor to synchronize spray outputs to tree structures. *Trans. ASABE*, 55(3), 773-781.

Liu, H., Zhu, H., Shen, Y., Chen, Y., & Ozkan, H.E. (2014). Development of digital flow control system for multi-channel variable-rate sprayers. *Trans. ASABE*, 57(1), 273-281.