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Performance Evaluation of a Newly Developed Variable-Rate Sprayer for Nursery Liner Applications

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Abstract. *An experimental variable-rate sprayer designed for liner applications was tested by comparing its spray deposit, coverage, and droplet density inside canopies of six nursery liner varieties with constant-rate applications. Spray samplers, including water-sensitive papers (WSP) and nylon screens, were mounted inside tree canopies to collect spray deposit and coverage from variable-rate and constant-rate (555 and 1,110 L ha^{-1}) applications. Models for estimating spray volume savings of the variable-rate sprayer compared to constant-rate and tree-row-volume (TRV) rate applications were developed for various liner canopy sizes and tree spacings. The accuracy of the model was validated with the field test data. For the liner trees tested, the variable-rate sprayer delivered 151 to 359 L ha^{-1} application rates, while the conventional constant-rate application required 1,110 L ha^{-1}. Due to substantially lower spray output, the variable-rate application had lower (but sufficient) spray deposit, coverage, and droplet density than the constant-rate applications. The variable-rate application also had significantly less variations in spray deposit within canopies of different-size trees. Test results showed that the variable-rate sprayer reduced spray volume by up to 86.4% and 70.8% compared to the 1,110 L ha^{-1} and TRV-based rate applications, respectively, while the model-estimated savings were up to 94.6% for the 1,110 L ha^{-1} application and 57.7% for the TRV-based rate applications. Therefore, the newly developed variable-rate sprayer would bring great reductions in pesticide use and safeguard the environment for nursery liner production.*

Keywords. *Automatic sprayer, Pesticide application, Spray deposit, Spray volume saving, Ultrasonic sensor.*

Properly applying chemicals to nursery crops is essential to protect them from biological harm and maintain their quality. In addition, pesticide application is relatively economical, and application schedules can be flexible. In 2006, nursery and floriculture crop growers in the U.S. consumed 2.54 million kg of active ingredients (USDA, 2007). However, few application technologies have been specifically designed for nursery production because of the diversity of commercial production practices. Thus, it is common for nursery growers to use either orchard or modified ground sprayers for their chemical application needs.

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Growing tree liners is a specialized business for some ornamental nurseries. These young trees are grown in densely planted rows for two to three years and then sold to other nurseries who then transplant and grow them to market size. Because of their rapid growth in a confined space, pesticide applications are needed to protect them from insect pests and diseases.

Conventional high-clearance, constant-rate sprayers with two vertical spray booms for each row of liners are normally used for applying chemicals for liner productions. However, variations in tree size and varieties invariably confound spray applications, and overapplication of pesticides is always possible. Sprayers that can automatically adjust application rates to match liner canopy height and volume are needed to improve application efficiency for this special nursery production system.

The key requirements for an automated sprayer are its ability to accurately detect the presence and size of tree liners. One promising technology to achieve this requirement is light detection and ranging (LIDAR) (Wei and Salyani, 2005; Lee and Ehsani, 2008; Rosell Polo et al., 2009). However, a LIDAR system requires sufficient row spacing to detect the tree canopy. This sufficient row spacing is not available in nursery liner fields where the tree row spacing is normally 1.2 to 1.5 m and gaps between rows are filled with liner foliage during the growing season.

Another technology used for detecting tree canopies is ultrasonic sensors, which have been widely used in automated experimental and commercial sprayers to control application rates (Giles et al., 1987; Moltó et al., 2000, Solanelles et al., 2006; Gil et al., 2007; Balsari et al., 2008). Moltó et al. (2000)