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Effect of emitter type and mounting configuration on spray coverage for solid set canopy delivery system

Ajay Sharda [a,*], Manoj Karkee [b], Qin Zhang [b], Igor Ewlanow [c], Ute Adameit [c], Jay Brunner [d]

[a] Department of Biological and Agricultural Engineering, Kansas State University, Manhattan, KS, United States
[b] Center for Precision and Automated Agricultural Systems, Biological Systems Engineering, Washington State University, Prosser, WA, United States
[c] Beuth University of Applied Sciences, Berlin, Germany
[d] Tree Fruit Research and Extension Center, Department of Entomology, Washington State University, Wenatchee, WA, United States

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ABSTRACT

Timely and precise application of chemicals is critically important for improved pest control and reduced off-target movement of chemicals. A fixed or solid set canopy delivery (SSCD) system with emitters within a tree canopy has potential to reduce chemical loss and cost by applying right amount of spray at right time and location under favorable ambient conditions. The study was conducted to quantify spray coverage using various emitters mounted at different configurations within tree canopy using a SSCD system. Six different emitter (E) types with varying characteristics were selected for a field study. Each emitter was installed in four different mounting configurations. Water sensitive cards (WSCs) were mounted on upper- and under-side of leaves at 22–25 locations on each tree. After spray application, the WSCs were scanned and analyzed for percent coverage. The configuration with 80° hollow cone emitters (E6) attached to a Y-connector and mounted at height of 2.0 m from the ground exhibited greater mean coverage on the WSCs placed on upper-side (58%) and under-side (21%) of leaves as compared to other emitter and configurations. It was found that coverage with this arrangement was nearly equal in upper (57.5%) and under-side (51.3%) of leaves in the high canopy region, which was the area where emitters were spraying directly. Therefore, configuration using E6 on Y-connector provided the desired uniform canopy coverage, however emitters at more locations would have to be installed to achieve similar coverage in the medium and low canopy regions.

1. Introduction

Airblast sprayers have traditionally been used for orchard spray application. These sprayers are set to operate at application pressure as high as 1400 kPa to provide canopy coverage from 23% (Cross et al., 2003) to 75% (Landers, 2008) depending on canopy density and training system. The application pressure and dosage are seldom set to match the tree geometry (Cross, 1991; Giles et al., 1989; Wiedenhoff, 1991). As a result much of the pesticide is lost and deposited on the ground or lost as volatile compounds. Cross et al. (2001a, b), investigated the effects of spray droplet size and application volumes on spray deposit in an apple orchard and reported that 43–61% of the applied spray was lost to ground deposit within 4.6 m of the row being sprayed. The study also concluded that application volume with orchard sprayers varied so much that differences in selected emitter type have very little effect on deposition. The reason for the lack of effect of emitter type on deposition was because volume of spray used saturated the trees completely and excess spray simply trickled down the tree resulting in loss. In the state of Washington, there is a growing concern of harmful effects of pesticide runoff from orchards into aquatic systems, like the Columbia River and its tributaries. Therefore, there is a need to devise an alternate system to deliver pesticides, and nutrients which has a potential to provide uniform canopy coverage, and reduce spray loss and environmental pollution.

A solid set canopy delivery (SSCD) system has potential as an alternative method of precision and timely delivery of pesticides while providing equivalent spray coverage compared to orchard airblast sprayers in tree fruit orchards. A SSCD system is a fixed spray application system consisting of hoses and emitters through which a spray solution is delivered. Since emitters in a SSCD system are installed within tree rows, spray droplet could deposit quickly on tree canopy. An automated fixed or portable mixing and injection system including a pump connected to the SSCD system

* Corresponding author. Address: Ajay Sharda, 140 Seaton Hall, Manhattan, KS 66506, United States. Tel.: +1 785 532 2936.
E-mail address: asharda@ksu.edu (A. Sharda).

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would be as an integral part of the spray application technology for precision control of application rate. A SSCD system provides producers an opportunity to schedule a pesticide application when environmental conditions favor the least amount of drift and off-target movement. Additionally, pesticide applications can be conducted even when ground conditions are not favorable for driving through the orchard. This concept was initially tested by Lombard et al. (1966) using high flow impact sprinklers. Carpenter et al., 1985 presented design consideration for setting up a permanent spray application system. The authors concluded that a single sprinkler permanently mounted in the top center of each tree appeared to be an effective method of pesticide application. However the study provided little insight into pesticide coverage using different nozzles and indicated the need for further research. This approach of mounting sprinklers and/or nozzles in the top center of trees would potentially result in spray material loss to the ground.

Recent studies have reported potential for equivalent pest control efficacy with a SSCD system compared to a tractor-pulled air blast sprayer (Agnello and Landers, 2006). The study utilized one emitter type and mounting configuration and authors stressed further studies be conducted to understand spray distribution within tree canopy. Pesticide coverage throughout the tree canopy has been the concern in the fixed delivery systems tested by Lang and Wise (2010). However, spray coverage, among other factors, depends on the selection of appropriate emitter type and mounting configuration to achieve uniform tree canopy coverage. Therefore, knowledge of emitters, mounting configuration and its impact on coverage in different canopy regions would be critical for improving system design, commercial implementation and adoption of SSCD system. No study was found characterizing canopy spray coverage due to emitter types and mounting configurations for a SSCD system. Therefore this study was designed to study the spray coverage with various emitters and mounting configurations, which will provide the fundamental knowledge for designing an effective SSCD system. The two specific objectives of this research were to:

(1) Quantify spray coverage in upper-side and under-side of leaves in tree canopy using different emitter types and mounting configurations in a SSCD system, and
(2) Evaluate spray penetration within different regions of the canopy with those configurations.

2. Material and methods

2.1. Test site and spray system

The test site involved a four year old commercial apple orchard (pacific rose variety) located near Prosser, WA. The orchard was trained in super spindle architecture. The tree rows were spaced at 2.4 m with an intra-tree distance of 0.8 m resulting in a density of 5425 trees per ha. The tree height varied from 2.8 m to 3.0 m. A set of five trees were randomly selected for this study. The trees (Fig. 1) were morphologically different in regards to foliage and branches. Three middle trees were used to evaluate spray coverage and penetration. Spray coverage in this study was assessed for various vertical (height) regions of the tree canopy. Spray penetration, which refers to spray coverage in different lateral regions around central leader, was also assessed. The temperature and humidity were monitored to ensure that tests were conducted under environmental conditions that were consistent. A 6.0 m long spray section was installed on top trellis wire at a height of 2.9 m using 2.5 cm inside diameter polyvinyl (PVC) hose. A centrifugal pump (Model 1538, Hypro, New Brighton, MN) powered by a gas engine (Model GX 120, Honda Engines, Alpharetta, GA) pressurized liquid into the spray system. The pumping system was mounted on an orchard tractor (Model 4210, Deere & Company, Moline, IL). As mentioned before, the installation covered five trees in a row, out of which two trees in the boundaries were neglected from the coverage assessment study. Because the major goal of this study was to compare spray coverage with different emitters and installation configurations, spatial variability over larger area or larger number of trees was not considered in the study.

Fig. 1. Super spindle apple trees in the test site located in a commercial orchard near Prosser, WA.

Four emitter configurations were selected to quantify spray coverage and penetration (Fig. 2). For each configuration, six different emitters (Table 1; labeled E1 to E6) were selected based on their cone angle, spray pattern, and flow rate. Emitters E1 and E2 were micro-sprinklers used in surface irrigation while E3 through E6 were emitters used for delivery of pesticides in agriculture. The micro-sprinklers were selected based on initial studies conducted by Landers (2004) while commercial off-the-shelf emitters with different spray patterns (hollow cone and solid cone) and spray cone angles were selected to study the effect of these parameters on spray coverage in tree fruits. Teejet single emitter bodies (QJ17560A-NYB, Teejet Technologies, Wheaton, IL) were fitted on the PVC hose at an interval of 0.8 m. Emitters in configuration-1 and -2 were mounted directly on these emitter bodies. In case of configuration-3 and -4, a 0.8 m long polyethylene tube (PE Supply, Farmingdale, NY) with 0.4 cm inside diameter was connected to emitter bodies, hereafter termed as drop-down, to install emitters. In configuration-1, one emitter was mounted on the main hose and located at the center of each tree canopy. In configuration-2 one emitter was located in between two trees (Fig. 2). In configuration-3 a butterfly connector (Jain Irrigation Inc., Fresno, CA) was used to mount emitters E1 and E2, and a quick connect adaptor (Model QJ90-2-NYR, Teejet technologies, Wheaton, IL) was used to install E3 through E6 on the end of a drop-down. The quick connect adaptor has two mirrored outlets oriented at 45° to the horizontal to install emitters (E3 through E6). For configuration-1 through -3 emitters were oriented downwards. For configuration-4 a tee (Jain Irrigation Inc., Fresno, CA) was installed on the drop-down to mount two emitters in the vertical plane along the