Intelligent Sprayer and Disease-Warning Systems for Apple IPM

Tips for Growers

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Smart Apple Spraying
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Pesticides are a key tool in integrated management of apple diseases and insect pests. However, pesticide spraying is increasing costly and labor-intensive, and can pose health and environmental hazards. Two ways that growers can potentially reduce pesticide use and save money are by lowering the volume sprayed per application or by reducing the total number of sprays per season.

This Growers' Manual summarizes practical take-home messages from a three-year research project in Iowa and Ohio that evaluated both of these ways of conserving pesticides. We tested a new type of spray technology, the Intelligent Sprayer, to reduce the amount of spray applied during each spray trip. We also evaluated whether some spray trips could be eliminated by using two disease-warning systems—one for fire blight and the other for sooty blotch and flyspeck (SBFS)—to guide spray timing.

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The Intelligent Sprayer

Airblast sprayers have been the mainstay for spraying pesticides in tree fruit crops for many years. Spray rates for airblast sprayers are set by using driving speed, spray pressure, number and type of nozzles, and orchard architecture to determine a fixed spray rate that is usually stated in gallons per acre (GPA).

A standard airblast sprayer does not adjust spray output in response to variations (in tree size, tree gaps, canopy density, etc.) in each orchard block. As a result, a considerable portion of the spray from this type of sprayer misses the target and becomes off-target drift.

In contrast, the Intelligent Sprayer (**FIGURE 1**) uses a laser scanner to enable it to "see" entire trees and adjust spray output automatically. By retrofitting the Intelligent Sprayer hardware onto a standard airblast sprayer, the sprayer becomes responsive to a tree's shape, size, and foliage density.

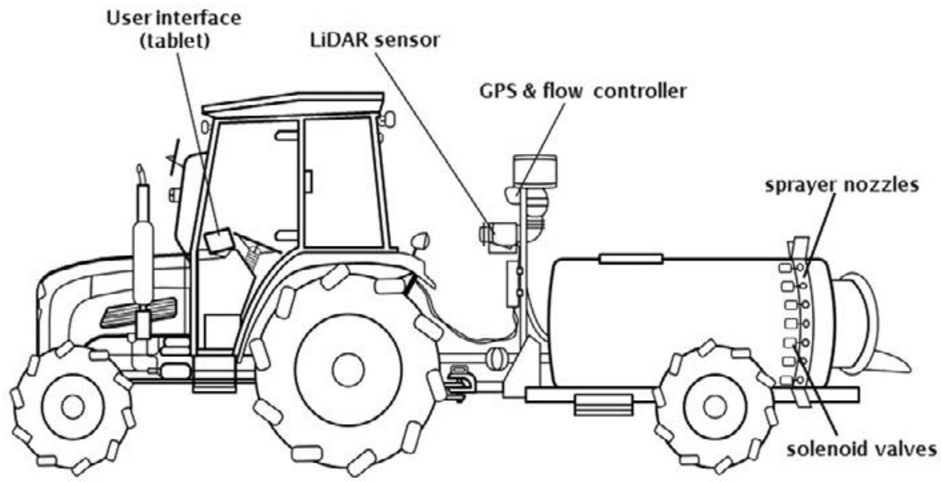

FIGURE 1. ***Schematic of some key components of the Intelligent Sprayer.***

This technology has been commercialized by **Smart Apply**® (Indianapolis, IN; https://smartapply.com) in sales partnership with John Deere and other dealer networks. A retrofit kit for converting a standard airblast sprayer features a software package called SmartApply and a series of hardware parts such as a LiDAR (laser imaging, detection, and ranging) scanning sensor, a flow controller, Global Positioning System (GPS), and individual "pulse-width-modulated" solenoid valves that can regulate each nozzle's spray output separately (**FIGURE 1**). The system is controlled by a tablet computer located in the tractor cab.

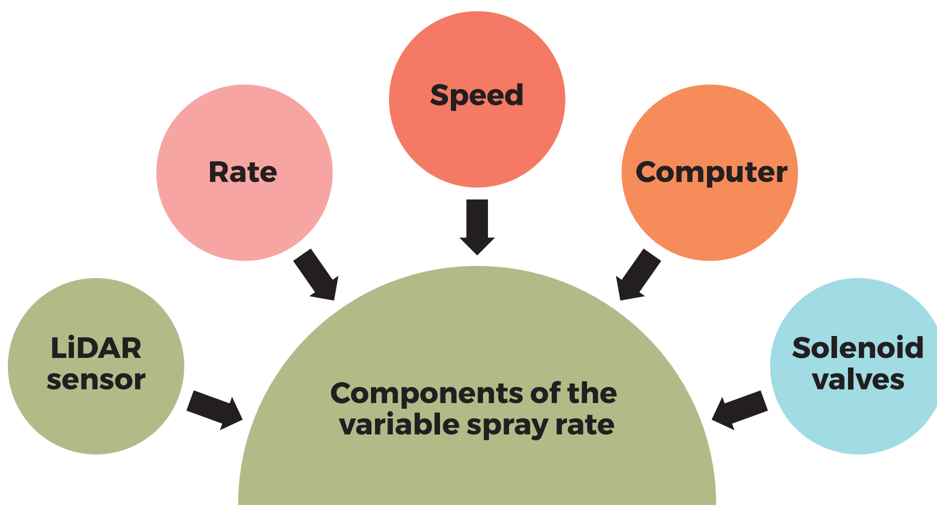

FIGURE 2. ***Factors that go into calculation of the Intelligent Sprayer's variable spray rate.***

The Intelligent Sprayer uses LiDAR sensor readings to create a 3-D scan of individual trees. These data are then fed to a computer that commands the nozzles to provide pulsing outputs according to the target. Spray drift is minimized because spray is applied only when and where it is needed. Another key difference from a standard airblast sprayer is that the Intelligent Sprayer discharges variable spray rates that match the spray volume to the density of the canopy (**FIGURE 2**). The base spray rate is set in

“[The Intelligent Sprayer] has worked very good. As far as pest control we have not noted any difference between the conventional spray system and the Intelligent Sprayer . . . we are saving up to 50% of our chemical use and that’s quite a bit of money, plus it’s safer for the environment.”

—Ohio grower with a ~200-acre apple and peach farm

fluid ounces of spray to cover per volume of canopy (fluid oz/ft^3). This is a different approach than for standard airblast sprayers, which are adjusted to apply a certain number of gallons of spray per acre.

Field trials in Iowa and Ohio showed spray volume reductions of 30 to 60% on semi-dwarf apple orchards compared to a standard airblast output of 100 gallons per acre, while showing no difference in insect pest and disease incidence. These trials were conducted in university orchards in both states and in demonstration plots in commercial apple orchards in Ohio.

Calibration

The calibration process for the Intelligent Sprayer is much simpler than for a standard airblast sprayer. A standard airblast sprayer needs calibration to ensure predetermined application rates (for example, 100 gallons per acre) before spraying trees. For the calibration process, it is necessary to determine sprayer travel speed, measure spray swath, decide how many nozzles will be used, and measure/adjust nozzle flow rates by adjusting pressure to match the predetermined application rate.

In contrast, the Intelligent Sprayer does not need this calibration process. Instead, it needs to measure only individual nozzle flow rates at the set pressure as inputs for the initial settings. This is because the Intelligent Sprayer automatically adjusts the spray output “on the fly” (in real time) in response to the characteristics of the orchard canopy.

Maintenance tips

For proper functioning, the LiDAR sensor lens needs to be kept clean. Dust, pesticide residue, and scale deposits can impair performance of the Intelligent Sprayer. A microfiber lens cloth and a glass cleaner can be used to clean the lens before going into the orchard. After spray tasks, the sprayer should be triple-rinsed with clean water to prevent nozzles and spray lines from clogging. It’s a good idea to check nozzle flow rates at the set pressure once a year to verify that they match the initial settings shown on the computer screen. If they are different, it’s time to clean the nozzles or replace them.

The software and getting ready to spray

The Intelligent Sprayer software, called Smart Apply, is loaded onto the sprayer’s tablet computer (**FIGURE 1**). Prior to spraying you will need to select the base spray rate (in fluid ounces per cubic foot of canopy) that you want to use in a given orchard block. For apple trees, we have used rates of 0.06 or 0.09 fl oz/ft^3 and obtained disease and insect control comparable to a standard airblast sprayer calibrated to deliver 70 to 100 GPA. For the first few sprays, it’s advisable to place water-soluble papers in a few trees to verify that the spray pattern is being applied uniformly.

The tree row width—the distance from the center of the alley to the center of the tree row (**FIGURE 3**)—also needs to be input before spraying. Note: We recommend adding 2 ft to this row width measurement in order to ensure that the laser beams reach the entire facing side of each row of trees. This means that if your tree row width for each side is 14 feet, you would want to set up the laser width for each side at 9 feet (14/2 = 7 feet + 2 extra feet = 9 feet) (**FIGURE 3**).

We advise against doubling the row width calculations in an attempt to cover two rows at a time and then spraying every other row, as this may compromise spray coverage and pesticide effectiveness.

Spray savings and optimized coverage

The Intelligent Sprayer can save on spray volume compared to a standard airblast sprayer. But how good is it at providing coverage of the apple trees? Our studies show no difference in percentage spray coverage when comparing a standard airblast sprayer at 100 GPA to the Intelligent Sprayer at a rate of 0.09 fl oz/ft^3.

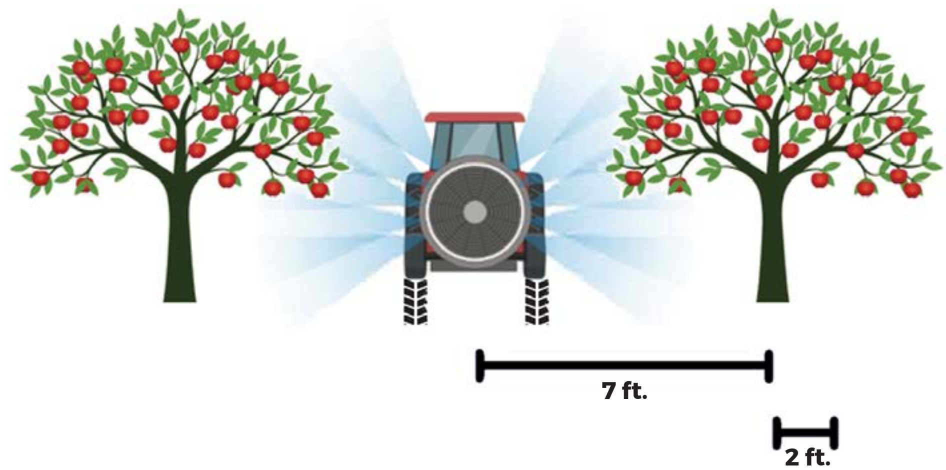

FIGURE 3. ***Schematic diagram of laser width selection when setting up the Intelligent Sprayer mode in the SmartApply program. Distance between center of the tree row and center of the alley should be measured, and an extra 2 feet should be added to that distance.***

Disease-warning systems for fire blight and sooty blotch and flyspeck (SBFS)

Researchers have developed disease models that recommend applying a spray (fungicide or bactericide) according to the risk of a disease outbreak. Our project worked with disease-warning systems for fire blight (caused by the bacterium *Erwinia amylovora*) and sooty blotch and flyspeck (SBFS; caused by many species of fungi). Weather information is input to these warning systems; however, inputting reliable weather data is vital to getting reliable forecasts of disease risk. Weather information should represent what is actually happening on the farm. To achieve this, growers can use either estimates provided by regional networks (see section below on Forecasting Platforms) or make the weather measurements on their own farms (FIGURE 4). In either case, weather sensors need to function properly (good quality, installed correctly, and calibrated and maintained regularly).

Populations of the **fire blight** bacterium multiply quickly when conditions are humid and temperature is above 65 F. The highest risk for infection is during the bloom period. The **Maryblyt** warning system uses temperature, rainfall, and the tree's growth stage to predict the risk of an outbreak and advise whether a bactericide spray is needed. In our Iowa field trials, we saved one bactericide spray per year by using Maryblyt. You can download the **Maryblyt software program for free** at https://grapepathology.org/maryblyt or use it in conjunction with a forecasting platform such as NEWA or Enviroweather.

Sooty blotch and flyspeck (SBFS) is a fungal disease of the fruit surface. Wet periods (above 90% relative humidity) can set the stage for outbreaks. A SBFS warning system using a threshold total of 385 hours of relative humidity above 90% to time the second-cover fungicide cover spray saved 3 to 4 sprays per season during three dry growing seasons in Iowa. During wetter growing seasons, the number of sprays saved by the SBFS warning system is likely to be lower. In a very dry

How Intelligent Sprayer technology can be adopted

There are three ways to acquire Intelligent Sprayer technology. The cheapest one is a DIY option—buy the kit and do the installation yourself. The second option is to go to a local dealership (John Deere or others carrying this product) and have the hardware installed on a previously owned airblast. The third option is to buy a new airblast sprayer with the retrofit kit already installed.

FIGURE 4. ***Apple grower checking on his weather station.***

summer, if the spray threshold is not reached by 8 weeks after the first-cover spray, it's advisable to resume fungicide sprays on a calendar-timed basis in order to prevent any problems with summer fruit rots.

Forecasting platforms

In recent years, networks of forecasting platforms for management of insect pests and diseases in specialty crops have been developed by universities and growers, often in collaboration with each other. The two main examples in the Midwest and East are **NEWA** (https://newa.cornell.edu/) and **Enviroweather** (https://enviroweather.msu.edu/). These forecasting platforms use disease-warning models to issue spray advisories for apple scab, SBFS, and fire blight, as well as for insect pests like codling moth. Growers who want to access the full capabilities of these platforms usually pay an annual subscription fee. However, some states provide free access to these platforms; contact a University Cooperative Extension office in your state to determine if one of these platforms is available to you at no cost. Subscribers gain access to data from nearby weather stations, or they can install a weather station on their own farm. These platforms have gained wide use by apple growers in the Midwest and East.

Bottom line

We've been investigating two ways to save on pesticide sprays: targeted spraying using Intelligent Sprayer technology, and using disease-warning systems to apply sprays only when they are really needed.

Intelligent Sprayers will save significant volume with every pesticide spray due to more accurate targeting of the trees than a standard airblast, and warning systems can reduce the number of pesticide sprays applied in a season.

The initial capital outlay for Intelligent Sprayer technology is substantial, but it is likely to repay the investment for medium- and large-scale orchards within a short period of time. The adoption of disease-warning systems requires some time and modest expense to be able to use forecasting platforms like NEWA or Enviroweather.

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For questions about this publication please email the North Central IPM Center at **northcentral@ncipmc.org**

Glossary

- **Base spray rate:** The amount of spray volume in fluid ounces required to cover one cubic foot of tree canopy to obtain adequate spray deposition.
- **Intelligent Sprayer:** An airblast sprayer that has been retrofitted with the Smart Apply® software and hardware kit.
- **LiDAR:** Laser imaging, detection and ranging. A type of remote sensing method that uses laser pulses to measure distance and location of nearby objects.
- **Pulse-width-modulated solenoid valve:** Electromechanical device that uses electric pulses to modulate spray nozzle flow rates by regulating the opening and closing times of the nozzle.
- **Smart Apply®:** Intelligent spray control system developed by USDA-ARS ATRU at Ohio State University and commercialized by **Smart Apply Inc.** (https://smartapply.com/, Indianapolis, IN).
- **Spray coverage:** Proportion of the target surface that received the pesticide.
- **Tree row width:** The distance from the center of the alley to the center of the adjacent tree row.