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Retrofitting intelligent spray system on airblast sprayers for sustainable horticultural crop production

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Foliar Spray Application – most common method of delivery in modern crop production








Pesticide Spray Application Is a Complicated Process. Quality of Applications Depends on:

- Delivery equipment and methods
- Physical properties of spray formulations
- Type and amount of chemicals
- Types of pests and diseases
- Diversity of crops and their growth habits
- Operator skills
- Uncontrollable weather conditions
- Extensive worker safety and environmental regulations
- Cost-benefits of spray applications

Current spray practices have very low efficiency and require a complicated calibration process to determine the amount of chemicals to be used.

Laser-guided intelligent sprayer technology

Advanced and affordable spray systems that employ intelligent technologies with coordinated strategies to minimize human involvement in pesticide spray applications

Use individual tree foliage volume to control spray outputs of each nozzle instead of traditional gallons per acre

270° radial,
90-ft range

43,200 points/s

Convert point-to-point distances to surface structures

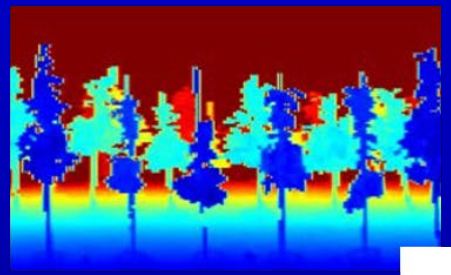
Each nozzle output is controlled by individual canopy foliage volume with 10Hz PWM valve:

$$Q_i = \frac{E_{vol}}{t} = \frac{h \cdot W \cdot v \cdot t \cdot \rho \cdot \nabla}{t}$$

$$= h \cdot W \cdot v \cdot \rho \cdot \nabla$$

Universal control system as a retrofit on sprayers

Commercial intelligent spray controller



Algorithms

Laser sensor

GPS

Air Filtration

PWM flow control valve

Flow controller

Android Tablet Display

Retrofit

Existing sprayers

Spray trials in an apple orchard

Conventional mode (45 gpa)

Automatic mode

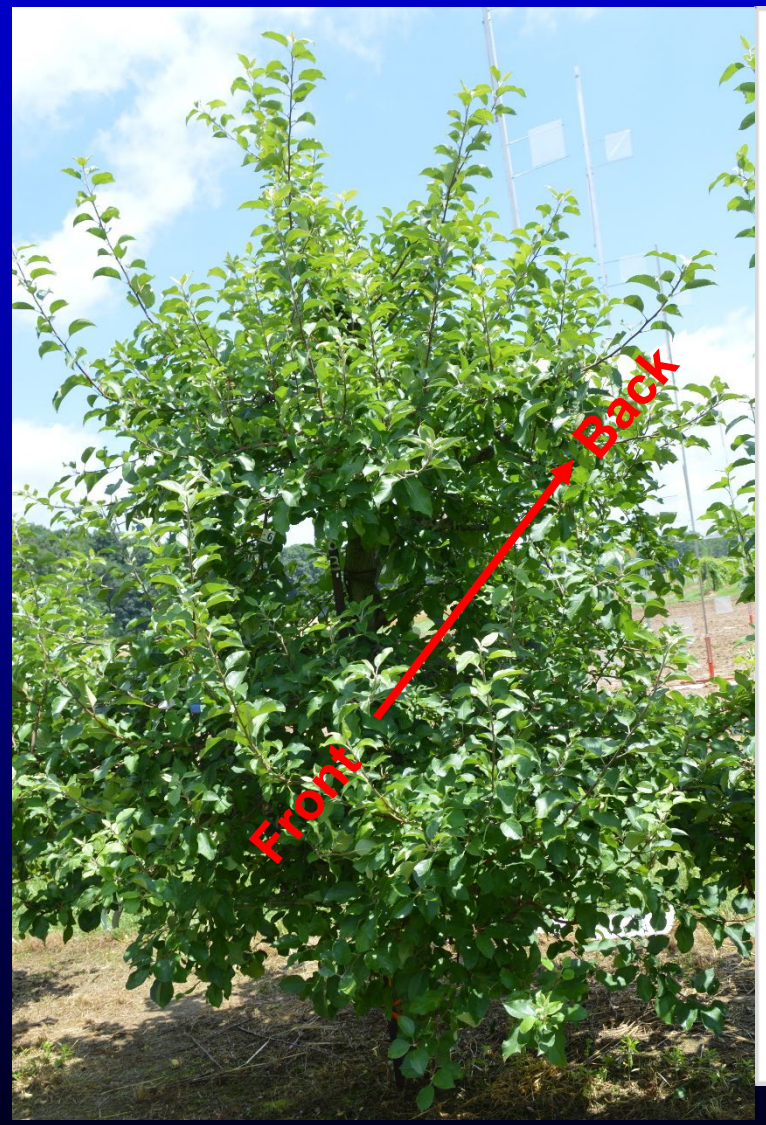
Total spray volume used for the test row

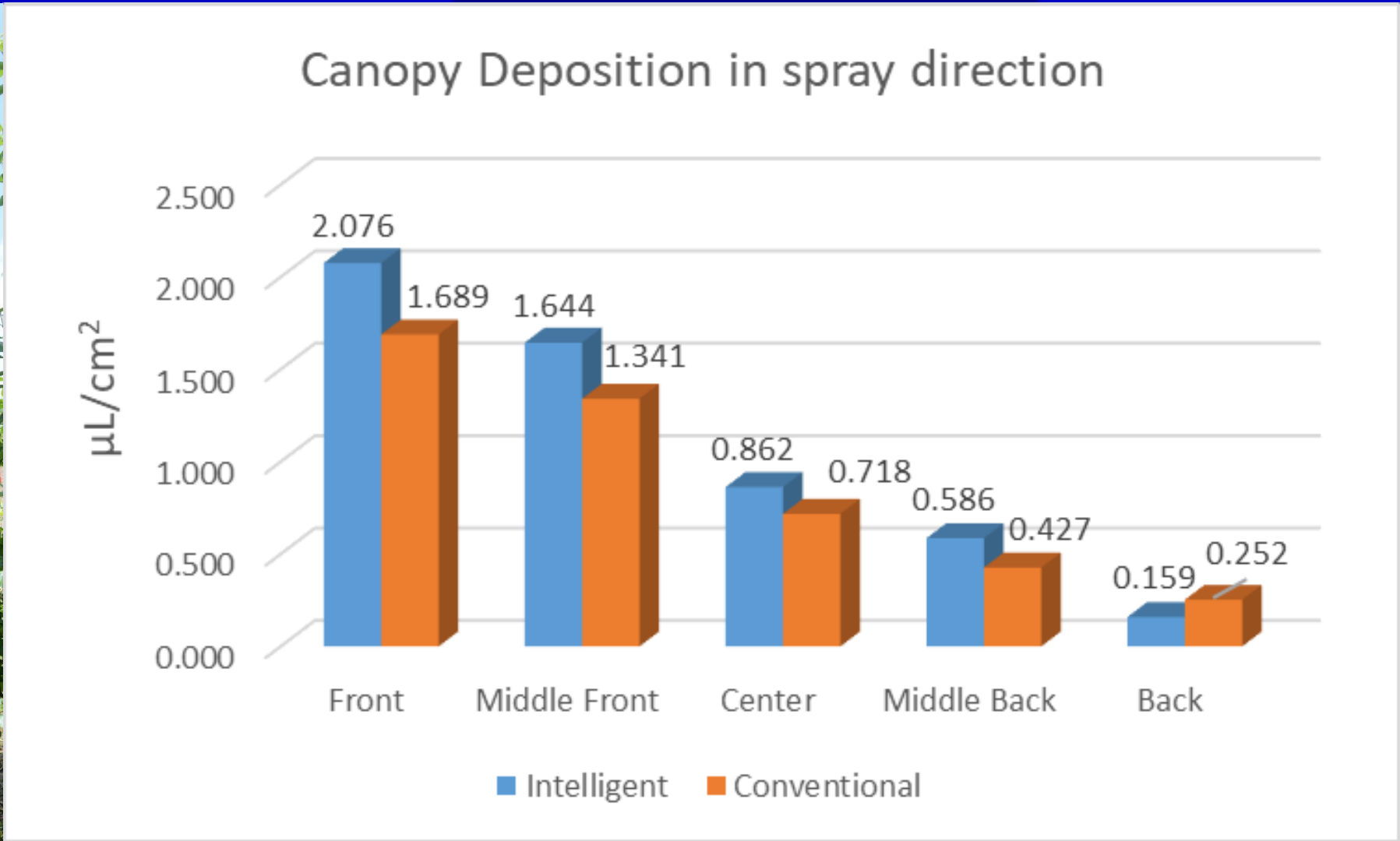
Conventional application: 3.3 gallon
Automatic application: 2.1 gallon

36% reduction

Examples of Results

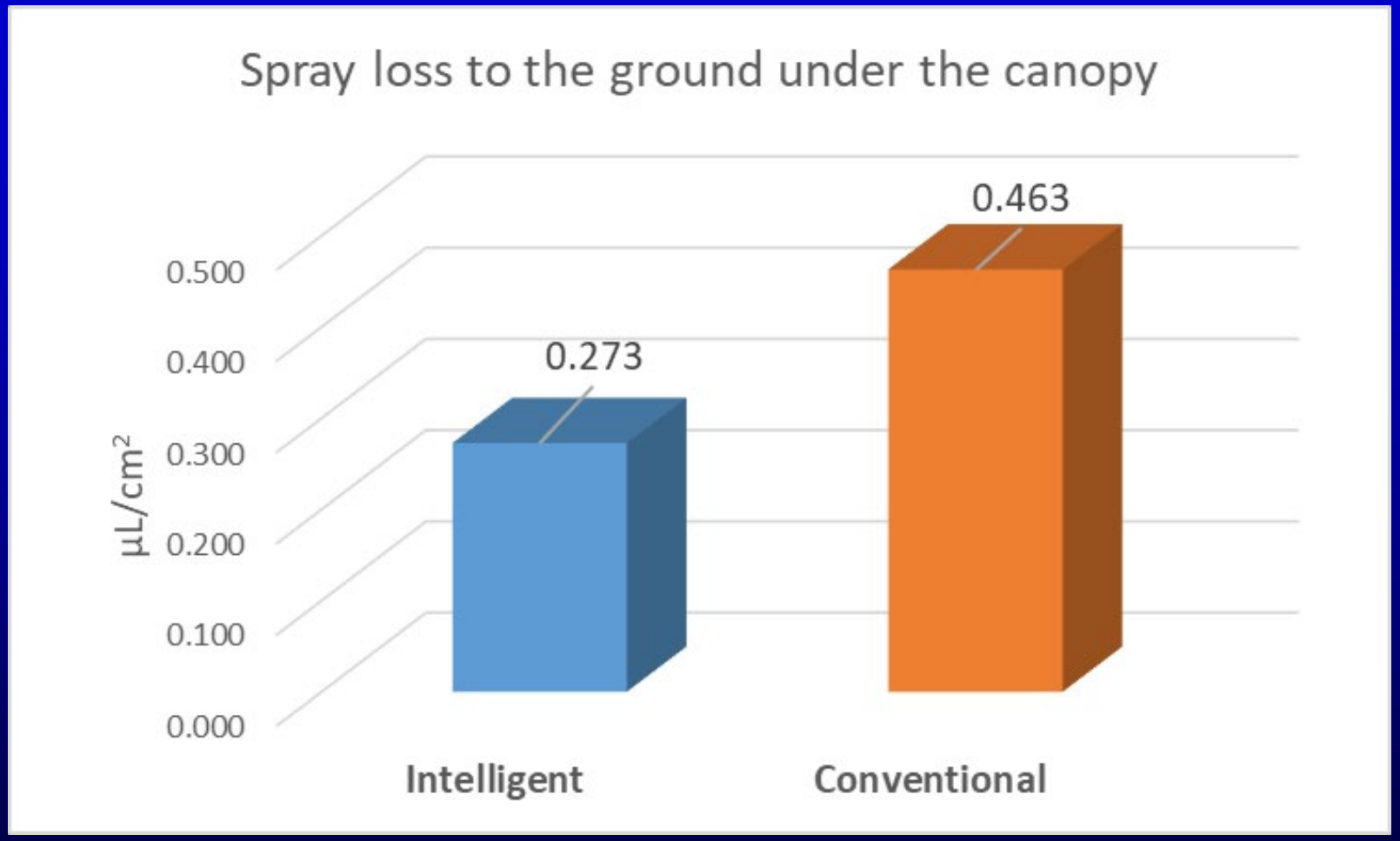
Canopy deposition





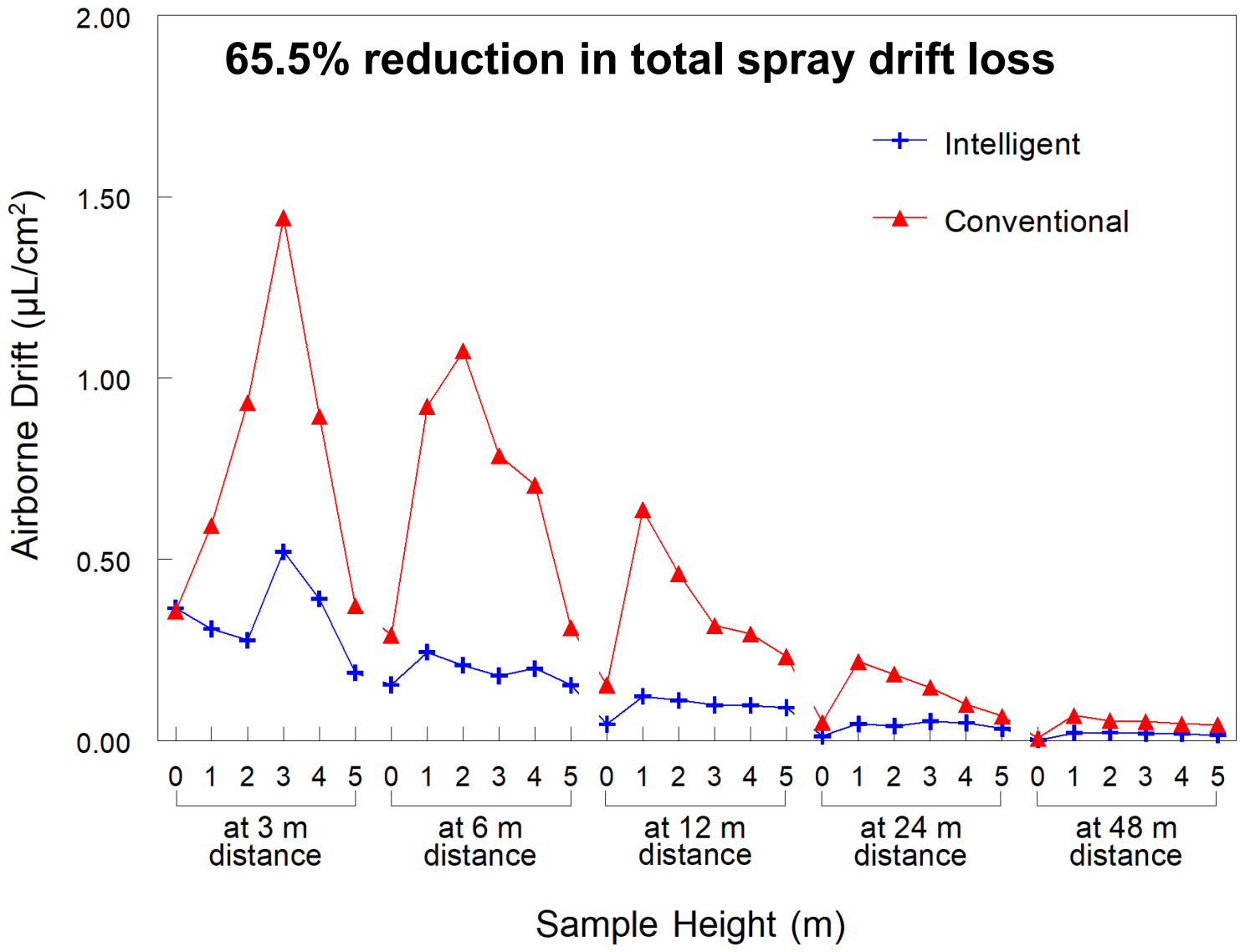
No significant difference

Ground Deposition Under Trees

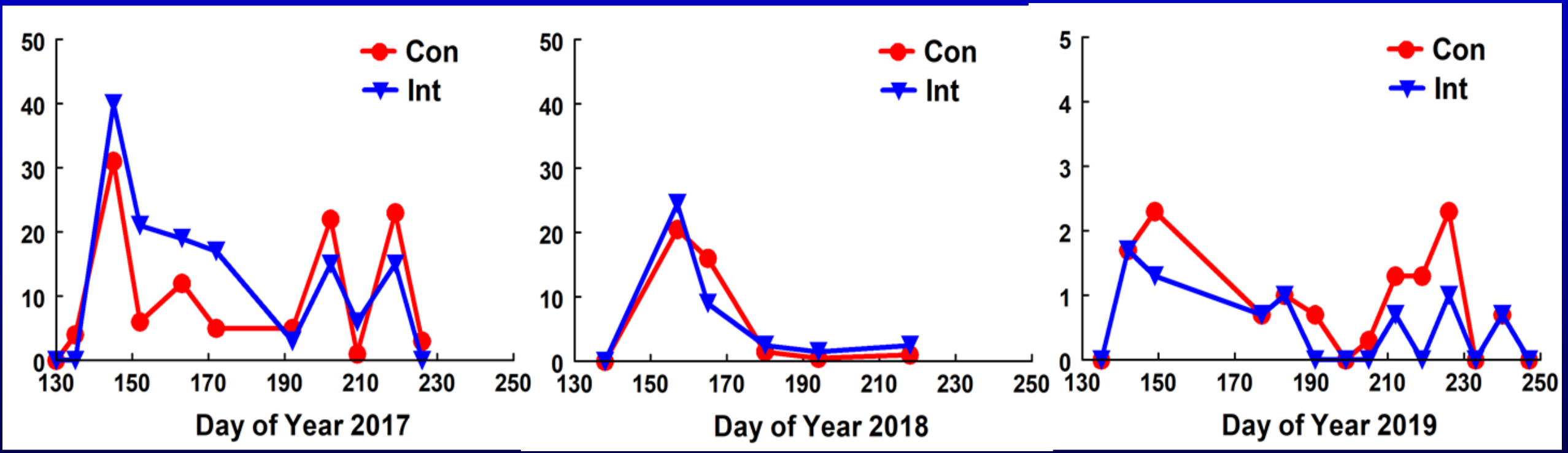


41% reduction in off-target loss under trees

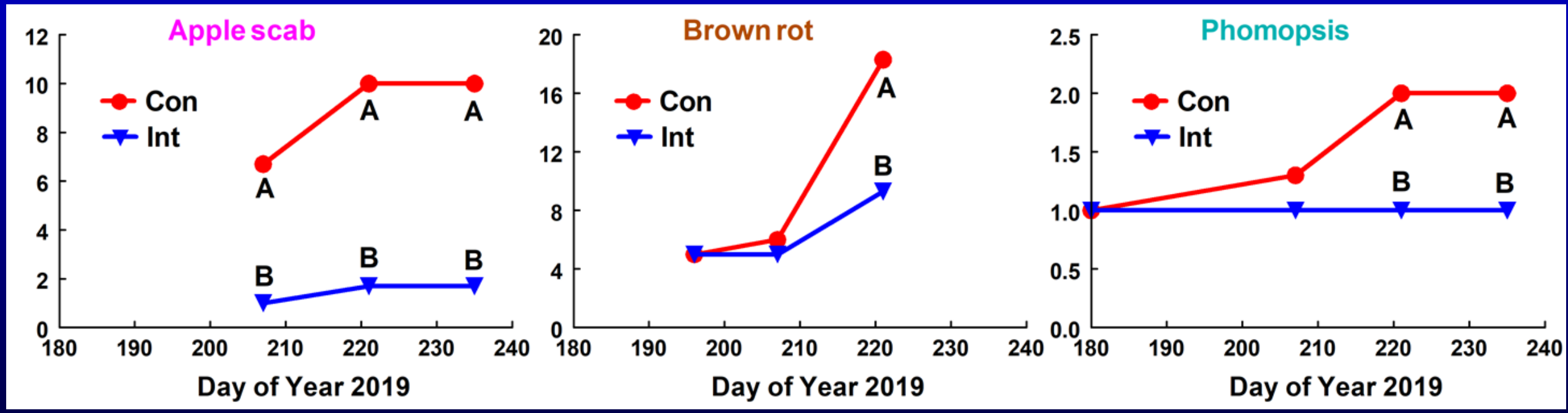
Airborne spray drift at different heights and different distances from the sprayed row



Average numbers of codling moths trapped in conventional constant-rate (Con) and intelligent variable-rate (Int) spray apple plots



Severity of diseases (%) of scab in apple trees, brown rot in peach fruits and phomopsis in blueberry plants treated with conventional constant-rate (Con) and intelligent variable-rate (Int) applications in 2019



Non-pathogenic fungi to thrive and compete with pathogenic fungi

Chemical reductions and cost savings with intelligent sprayers in an Ohio fruit farm

Spray volume reduction (%)				
Year	Apple	Peach	Blueberry	Raspberry
2017	64.8	23.7	44.4	49.4
2018	52.3	34.0	50.6	56.7
2019	32.1	32.0	55.7	55.3

Cost savings ($/acre)				
Year	Apple	Peach	Blueberry	Raspberry
2017	983	61	292	117
2018	755	220	289	81
2019	394	177	346	53

On-farm tests of the intelligent spray system in orchards, vineyards and nurseries in different states since 2013

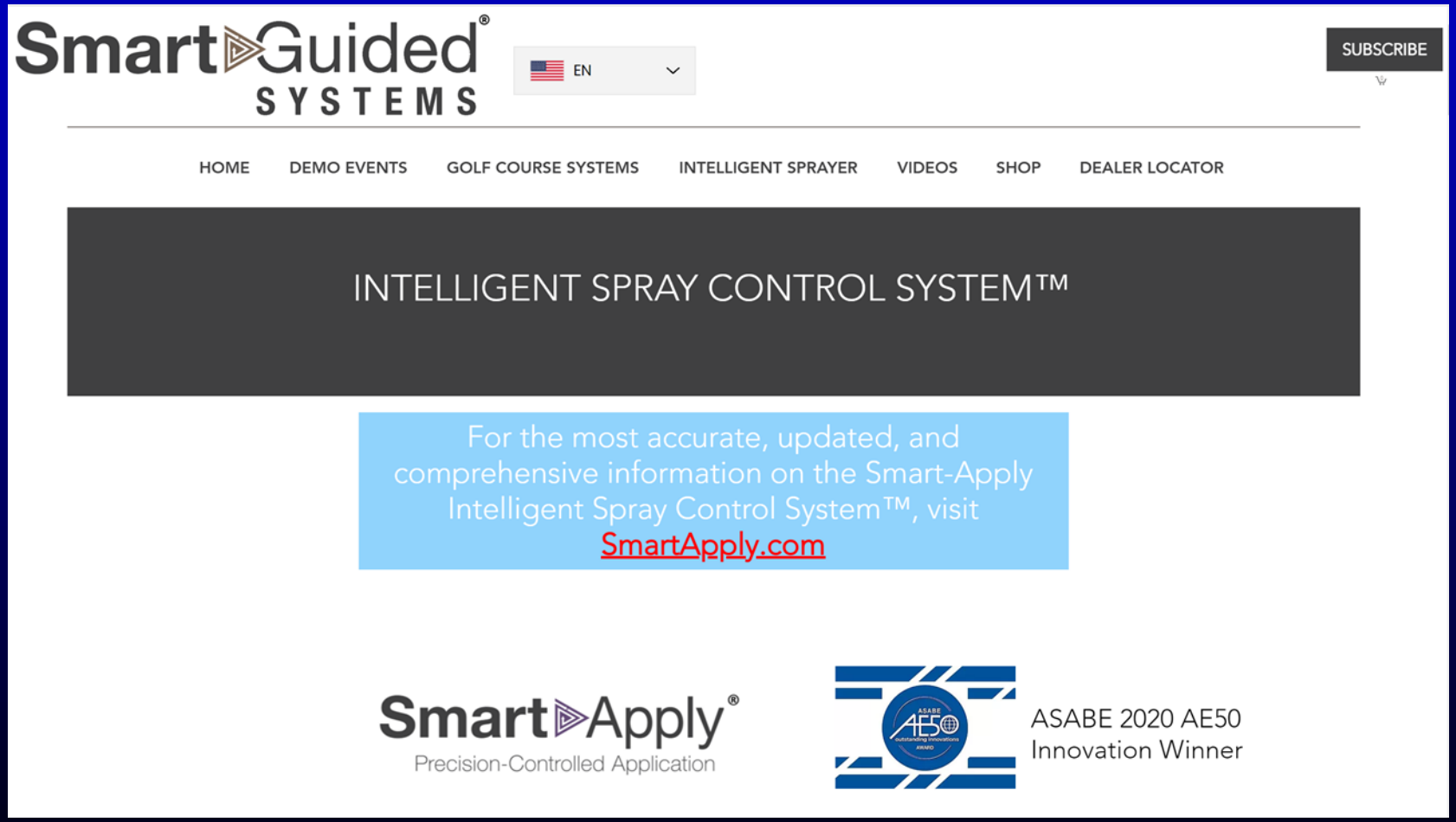
Wooden's Apple House in Tennessee
The Apple Barn in Tennessee
Bauman Orchards in Ohio
Moreland Fruit Farm in Ohio
Lynd Fruit Farm in Ohio
Blueberry Patch in Ohio
Klingshirn Winery in Ohio
Titan Peach Farm in South Carolina
5 R Enterprises (Pecan Farm) in Texas
Willoway Nurseries in Ohio
Herman Losely & Son Nurseries in Ohio
Klyn Nurseries in Ohio
Hans Nelson & Sons Nurseries in Oregon
J Frank Schmidt Nurseries in Oregon
Hale & Hines Nursery in Tennessee
Pleasant Cove Nurseries in Tennessee

Compared to conventional sprayers with comparable controls of insects and diseases, the intelligent sprayers:

1. increased spray deposition uniformity
2. minimized off-target losses (up to 87% reduction in airborne spray drift, up to 93% reduction in spray loss on the ground),
3. reduced pesticide use by up to 70%,
4. annual chemical savings by $50-$980 per acre.

Smart Guided Systems commercialized the intelligent spray control system (https://www.smartguided.com/)

Smart–Apply® Intelligent Spray Control System™



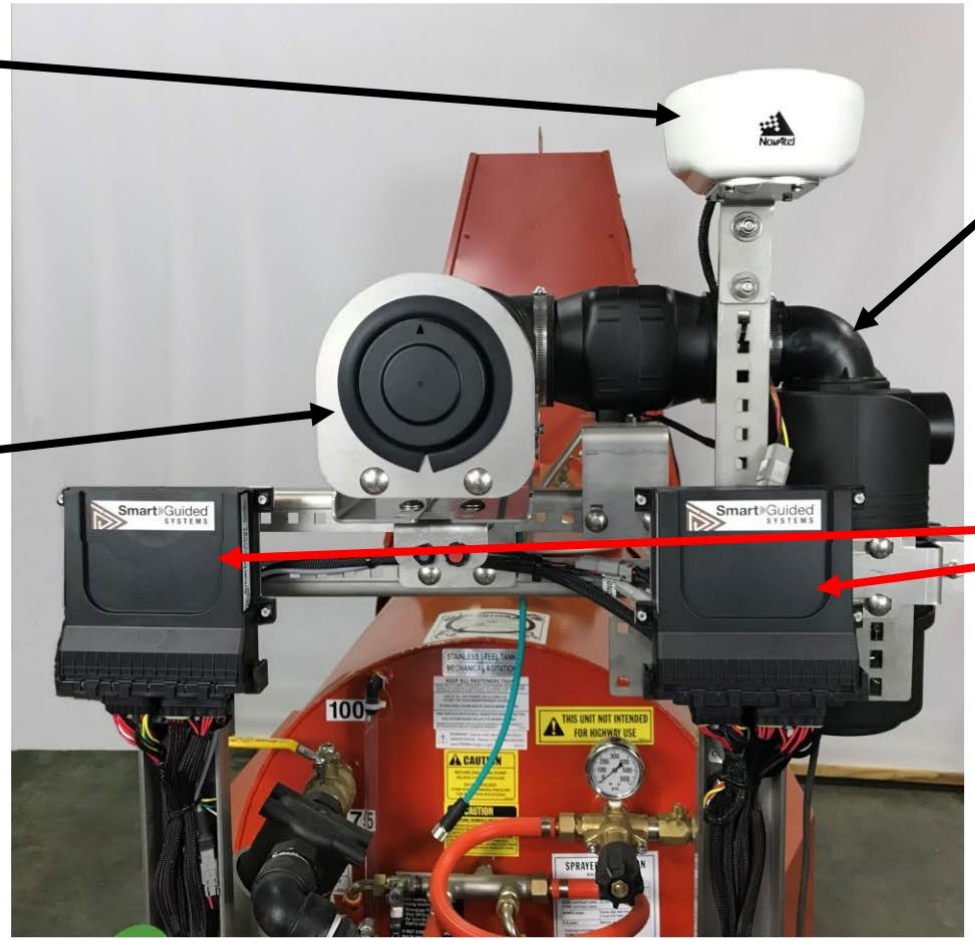
John Deere sells the product through dealer network.

Retrofitting intelligent spray control system

GPS for Speed & Coverage Maps

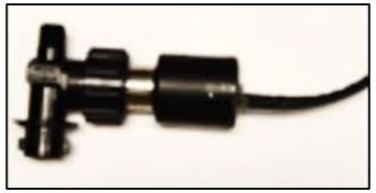
LIDAR (Laser)

Android Tablet Display

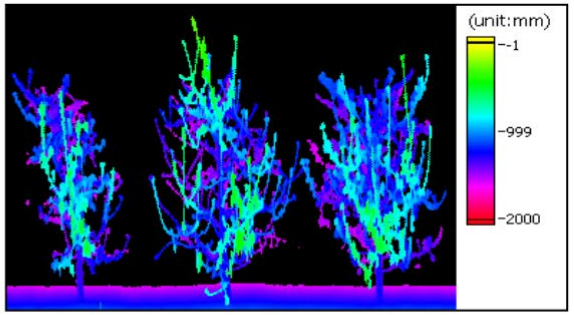


Air Filtration for LiDAR Lens

Controllers for Spray Nozzles



Nozzle Solenoids



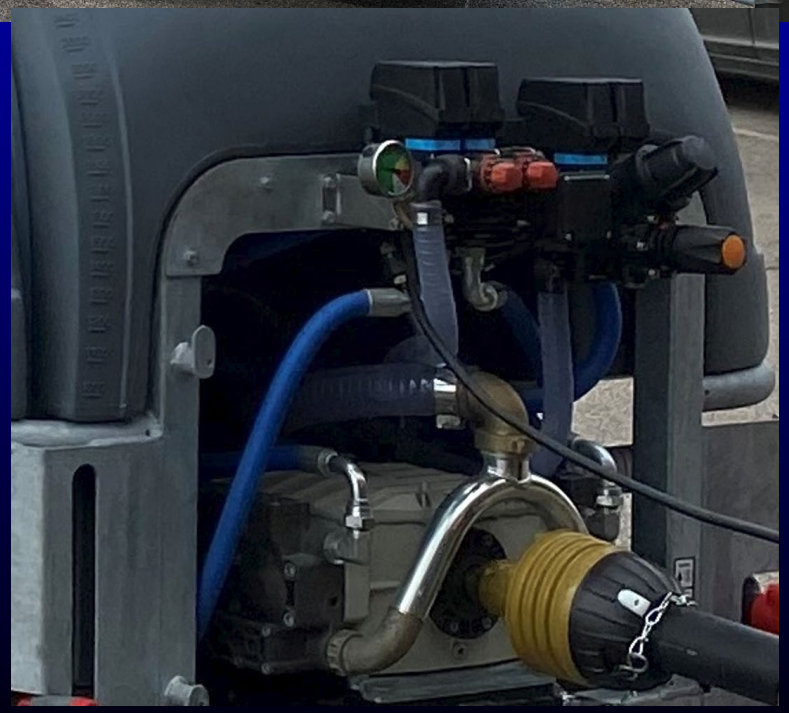
Algorithm's for Calculating Spray Volume

Retrofitting example

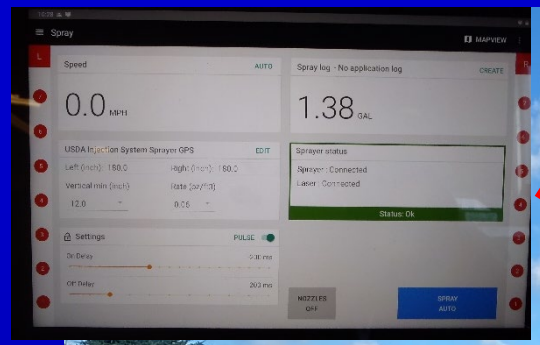
Original nozzle disc

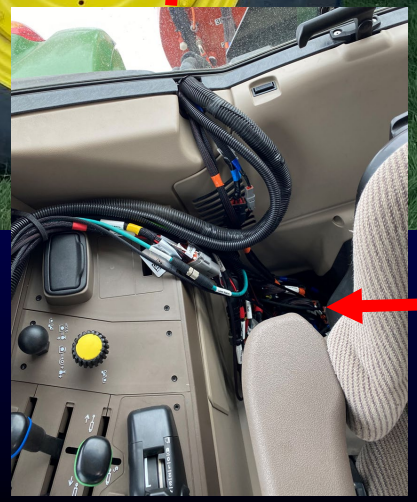
Attach a PWM solenoid valve to the nozzle body


Before retrofit
Rovic




After retrofit
SmartGuided
SmartGuided





Retrofitting example

Spray settings on tablet

LEFT NOZZLES

Number of nozzles : **9**

Nozzles offset :

NO.	BOTTOM HEIGHT	TOP HEIGHT	LASER DISTANCE	MAX.FLOW (GPM)	ENABLE
1	18.0	28.0	Distance	3.0283	✓
2	28.0	35.0	Distance	3.0283	✓
3	35.0	41.0	Distance	3.0283	✓
4	41.0	49.0	Distance	3.0283	✓
5	49.0	57.0	Distance	3.0283	✓
6	57.0	65.0	Distance	3.0283	✓
7	65.0	74.0	Distance	3.0283	✓
8	74.0	81.0	Distance	3.0283	✓

RIGHT NOZZLES

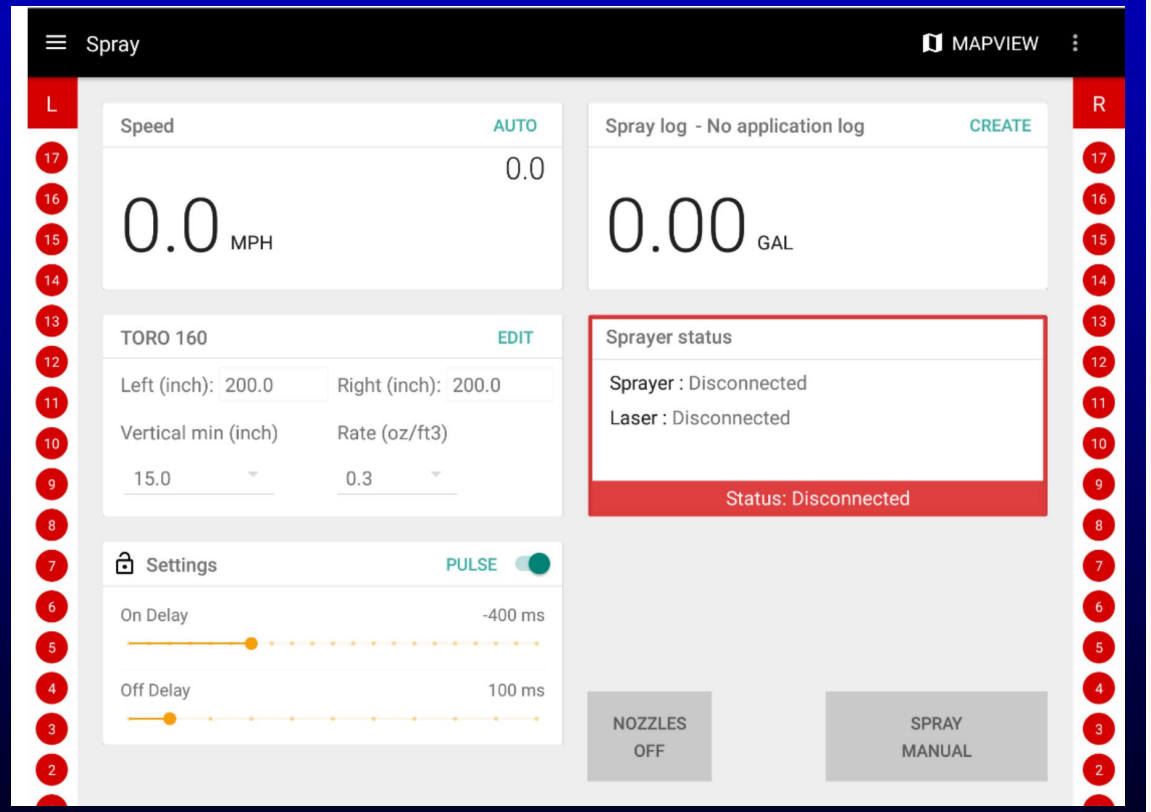
Number of nozzles : **9**

Nozzles offset :

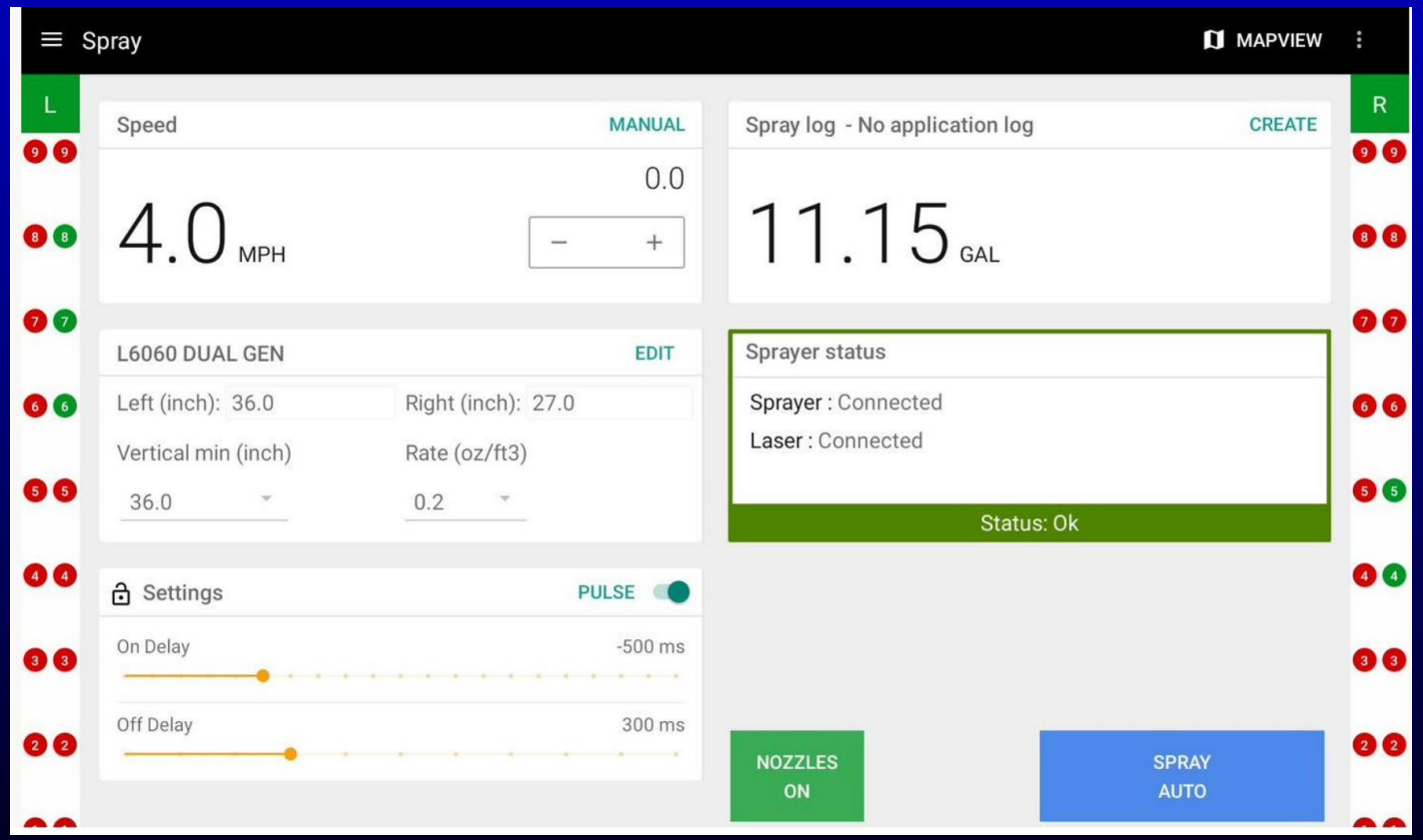
NO.	BOTTOM HEIGHT	TOP HEIGHT	LASER DISTANCE	MAX.FLOW (GPM)	ENABLE
1	18.0	28.0	Distance	0.2113	✓
2	28.0	35.0	Distance	0.2113	✓
3	35.0	41.0	Distance	0.2113	✓
4	41.0	49.0	Distance	0.2113	✓
5	49.0	57.0	Distance	0.2113	✓
6	57.0	65.0	Distance	0.2113	✓
7	65.0	74.0	Distance	3.0283	✓
8	74.0	81.0	Distance	3.0283	✓

Monitoring travel speed, spray volume applied, nozzle activations, and parameter settings through tablet screen

Before spray operation



During spray operation



Specialty crop growers have upgraded their standard sprayers with the commercial product for precision applications of pesticides and other foliar agents since 2019.

Crops:
- Apple
- Citrus
- Peach
- Hazelnut
- Pecan
- Grape
- Blueberry
- Raspberry
- Nursery

Countries:
- USA
- Canada
- Chile
- India
- Switzerland
- Australia
- New Zealand
- South Africa
- Mexico

Sprayers:
- Rear's Mfg
- Turbo Mist
- FMW
- Nelson Hardie
- Hardi: ZENIT
- TIFONE: Storm 2000

Dr. Mark Gleason leads investigations of intelligent sprayers to apply pesticides in apple orchards for IPM programs

iastate.edu Index Directory

IOWA STATE UNIVERSITY

Smarter Spraying for Apples

Smart(er) Apple Spraying podcast | Home | About | People | Blog | Project videos | Resources | Useful websites

Welcome to SmarterAppleSpraying!

This 3-year (2020-2022) project, involving Iowa State University, The Ohio State University, and USDA-ARS, is funded by USDA's Crop Protection and Pest Management (CPPM) Program.

Recent Blog Posts

Pesticide spray coverage: searching for the Goldilocks zone

Project's objectives are:

- Assess combining Intelligent Sprayer technology with warning systems for fire blight and summer diseases to achieve season-long pest and disease management of apples.
- Compare economic profitability and cost effectiveness of using the Intelligent Sprayer with disease-warning systems to current practices for control of apple diseases and arthropod pests.
- Share the projects' advances with apple growers in the eastern half of the U.S. through diverse outreach approaches and an IPM Information Portal.

https://www.smartapplespray.plantpath.iastate.edu/

Thank You! Questions?

For additional information, please contact Dr. Heping Zhu at HEPING.ZHU@USDA.GOV.