Progress in the Development of an In-Canopy Fixed Spraying System for High-Density Apple Orchards

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Conventional approach to pesticide application in apple orchards

Use of airblast sprayers can be inefficient and inaccurate:
- spray drift
- off-target contamination
- ineffective pest control
Microsprinkler arrangement for applying pesticides

- Metal conduit pole
- Plastic irrigation tubing
1999: Initial trials using fixed spray method
Study Site for
Fixed Spray
Evaluation, 2007

Fowler Farms
Wolcott, NY

- Mature ‘Gala’ block, 0.9 A
- “Super Spindle” planting system
- Row spacing – 10 ft
- Tree spacing – 2 ft
• Minimized number of branch points and reductions in tubing diameter to avoid excessive pressure loss between pump and nozzles.
• Attached nozzles directly to line within row
Lateral Line Support System

- No air-assist, limited canopy penetration; use in high-density plantings only
- Incorporated supply lines into tree support system
- Used dual (high and low) lateral lines, and sprayed from row center outwards
Supply Manifold Support System

Mounted supply line overhead, using rigid PVC pipe attached to the trellis support posts.
Could use airblast sprayer to pump the solution, but most sprayer pumps provide ~35 gal/min; need 3x that capacity

Built a mobile unit with tank and a suitable pump; transported to a central injection site
• Mixed pesticides with water in the main tank; pumped spray solution into tubing and through nozzles until desired amount (flowmeter) was deposited on trees. Flushed with clean water 24 hr later.
• Sprays made to half of block (~0.5 Acre, comprising 6 rows of fixed-spray system), using grower’s regular schedule of pesticides.
• Other half received same sprays applied with an airblast sprayer.
• Application process on each date required 2-3 minutes of operation.
• Compared pest control, thinning results, and spray deposition (dye).
Fruit Damage* at Harvest - 2007

* No significant differences between treatments
Spray Deposition on Foliage (µg/cm²)

- Fixed Spray
- Airblast
Complexities Needing to be Addressed

- Need better control of flow within the orchard piping for uniform and precise chemical delivery
- Chemical mixing and supply: controls needed to fill piping system with appropriate amount of spray material to wet canopy surfaces and give even application from the first nozzle to the last
- Emitter orientation & deposition: need uniformity in coverage among emitters, adequate canopy penetration, and an even spray pattern
- More practical way to eliminate residual spray solution from system

Considerations for commercial adoption:
- Efficiency in scaling up to practical size (pump, lines, nozzles)
- Seasonal maintenance needs
- Multi-season durability
- Economics: Total fixed cost (pumping unit) - $2283;
  Per-A cost (support structure, piping, tubing, nozzles) - $2176 per A
Initial Proposal for Design of Solid-Set Canopy Delivery System
Current System Modifications and Redesigns

- Installed pressure-compensating valves and leak-prevention nozzles to delay and synchronize emission of sprays at a target pressure after lines have been fully charged.

- Minimize non-target deposition by supplying each emitter with just enough spray material to adequately cover tree canopy surfaces below it.

- Use compressed air to recirculate and re-capture excess spray solution, effect spray delivery, and purge residue from lines.

- Spray material is delivered sequentially to small section of orchard at a time (1-2 rows; 15-30 sec each) from a pre-mixed tank, through irrigation lines fixed above each row.
Spray Application Process

- Pump used to fill all tubes and reservoirs from tank containing mixed spray materials
- Compressed air clears main supply tubes, returns excess material to spray tank
- Compressed air at a higher pressure opens check valves, all emitters spray out pesticide solution (15 sec for ~50 gal/A)
Potential Benefits

• Lower labor requirements, equipment upkeep possibly cheaper; potential for a greater degree of automation or precision operation

• Ability to spray in orchard conditions where tractor operation may not be optimal (e.g., early season, low-light hours; highly sloping blocks)

• Short application time:
  • take advantage of narrow application windows
  • multiple sprays and re-sprays much easier; can use short-residual (least-toxic) materials, sprayable pheromones; rescue treatments

• Minimal drift and off-target deposition; quieter operation; less impact on neighbors, adjacent property or roads

• Readily adaptable to use for irrigation, frost protection, sunburn protection
Acknowledgments

• Cooperating growers: John and J.D. Fowler, Fowler Farms, Wolcott, NY

• Irrigation specialists: Dr. Walid Shayya, SUNY-Morrisville; Dr. Ian McCann, Univ. of Delaware; John Nye, Trickl-Eez Co., St. Joseph, MI

• Funding Support: USDA Federal Formula Funds program, Northeast IPM Center; USDA SCRI Grant No. 2011-51181-31037