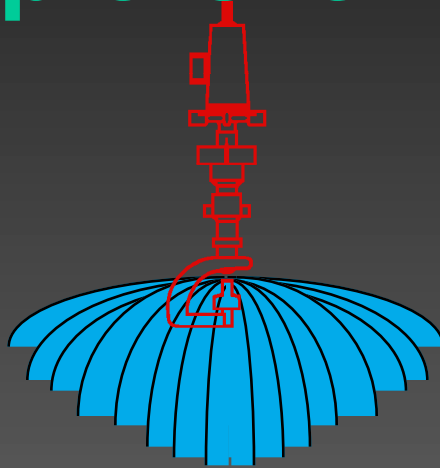


Progress in the Development of an In-Canopy Fixed Spraying System for High-Density Apple Orchards



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Conventional approach to pesticide application in apple orchards

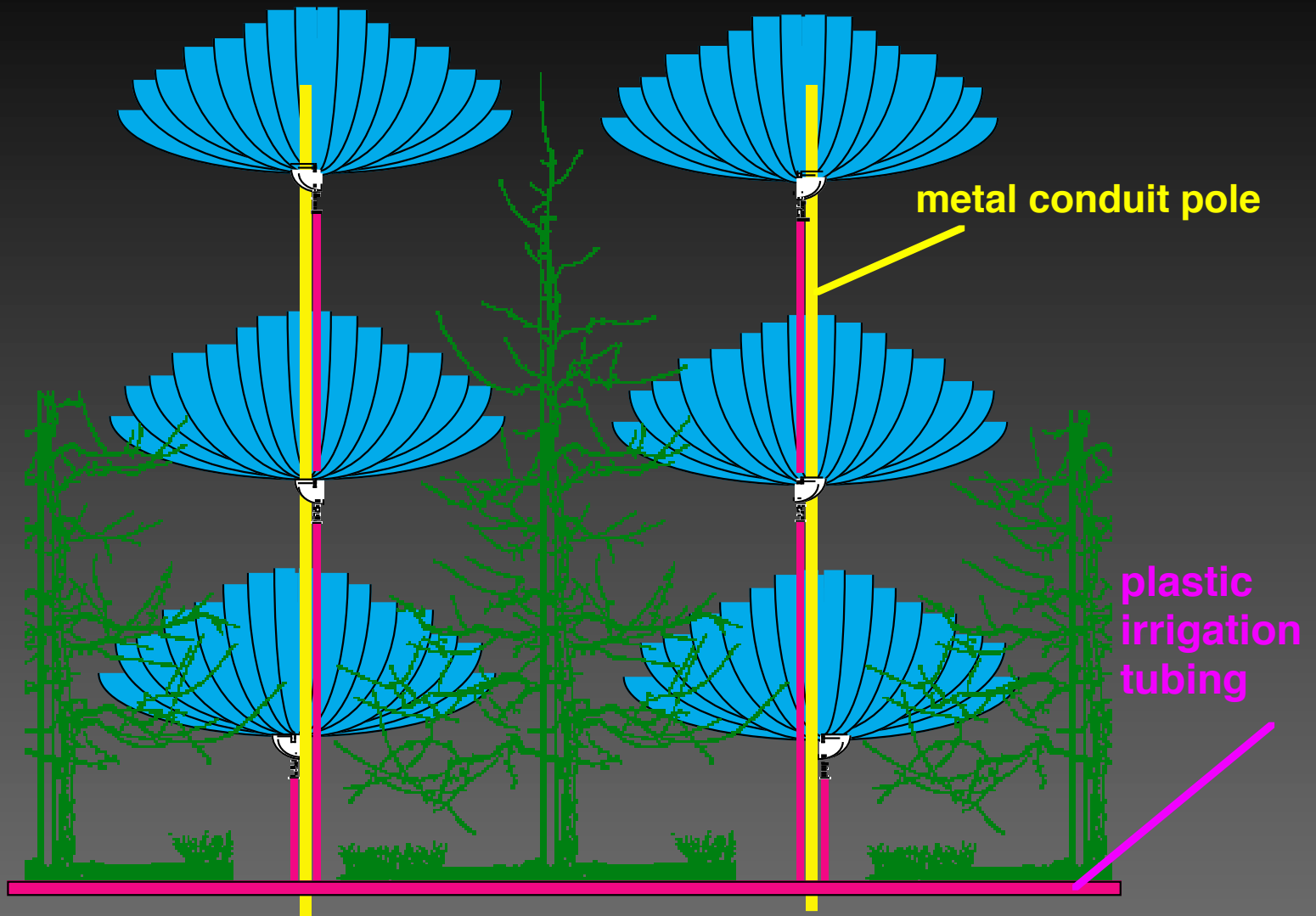


Use of airblast sprayers can be inefficient and inaccurate

- spray drift
- off-target contamination
- ineffective pest control



Microsprinkler arrangement for applying pesticides



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



$\frac{3}{4}$ -inch polyethylene tubing



- **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



**trellis
support
post**

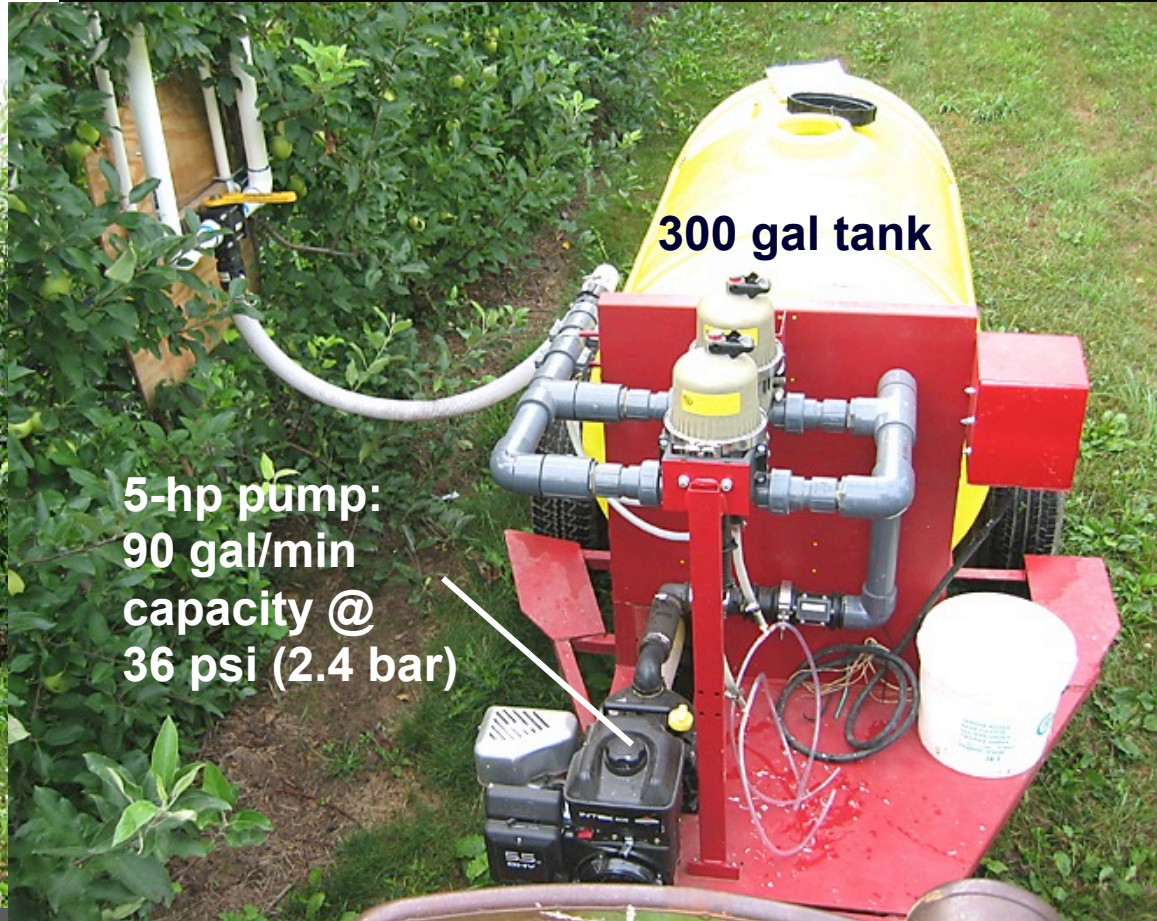
**2-inch PVC
Schedule 80
pipe**

**Mounted supply line
overhead, using rigid
PVC pipe attached to the
trellis support posts**

Pesticide Injection Site



Mobile Pumping Unit



- 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

Spray Applications



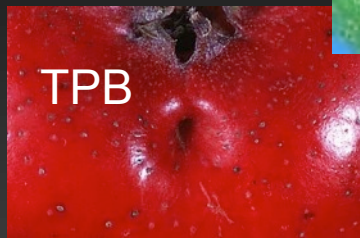
- Mixed pesticides with water in the main tank; pumped spray solution into tubing and through nozzles until desired amount (flowmeter) was deposited on trees. Flushed with clean water 24 hr later.
- Sprays made to half of block (~0.5 Acre, comprising 6 rows of fixed-spray system), using grower's regular 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).



OBLR



Plum Curculio



TPB



Apple Maggot



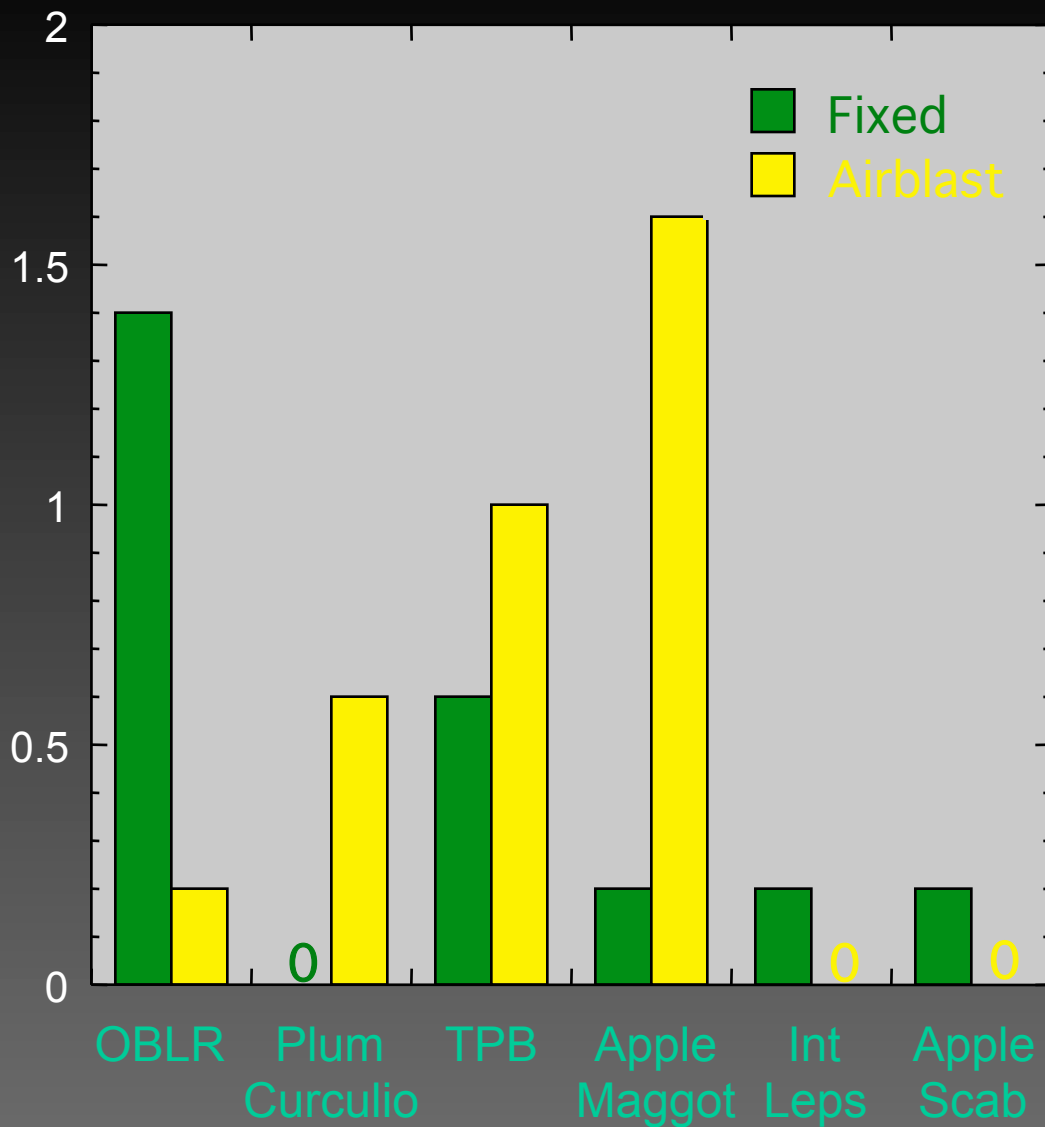
Apple Scab



Internal Lepidoptera

%
Fruit
Damage

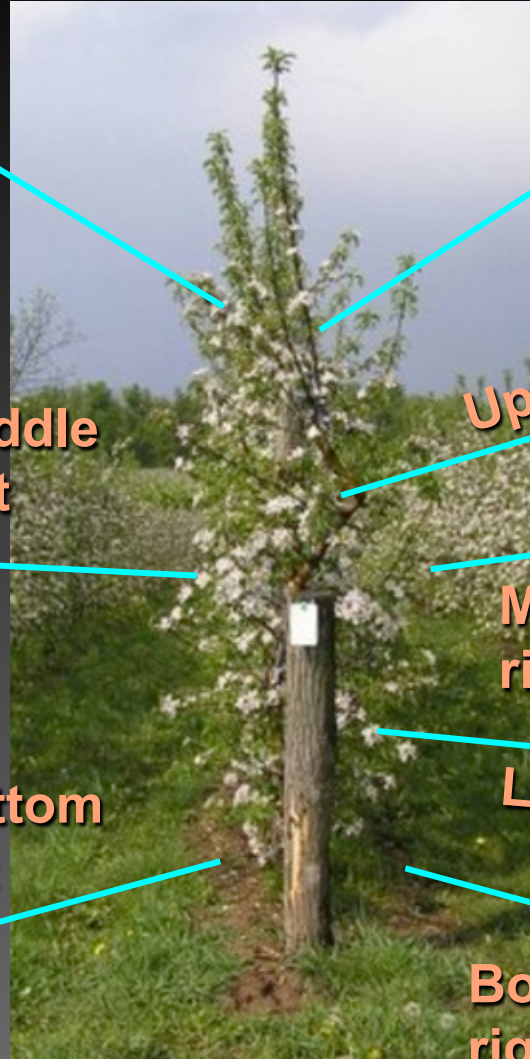
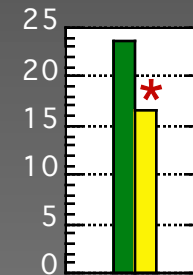
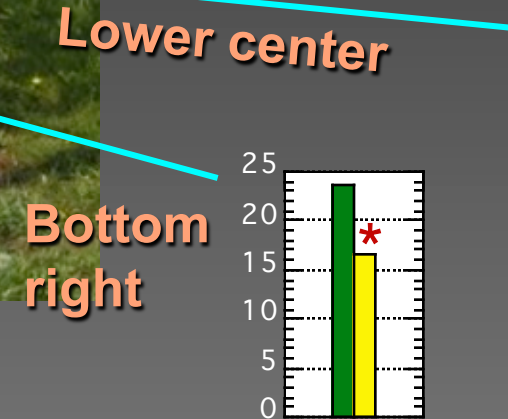
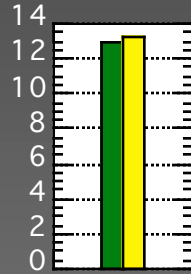
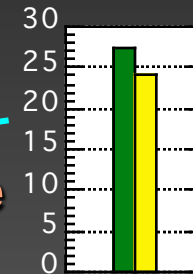
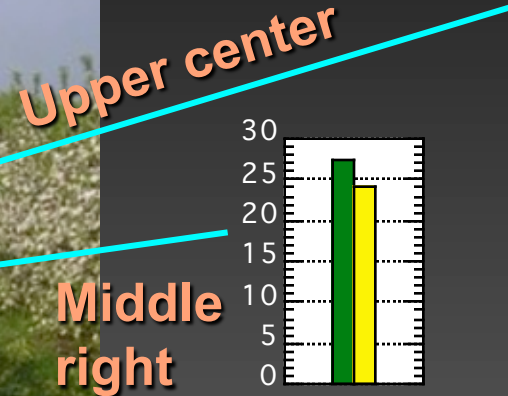
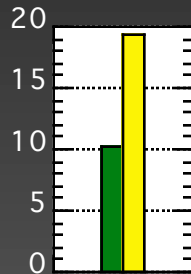
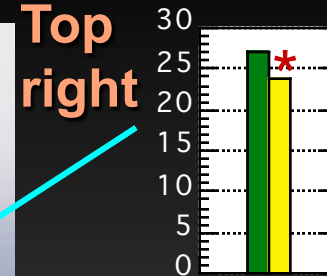
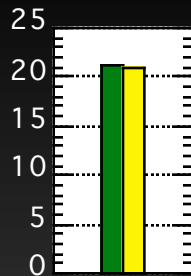
Fruit Damage* at Harvest - 2007



* No significant differences between treatments

Spray Deposition on Foliage ($\mu\text{g}/\text{cm}^2$)

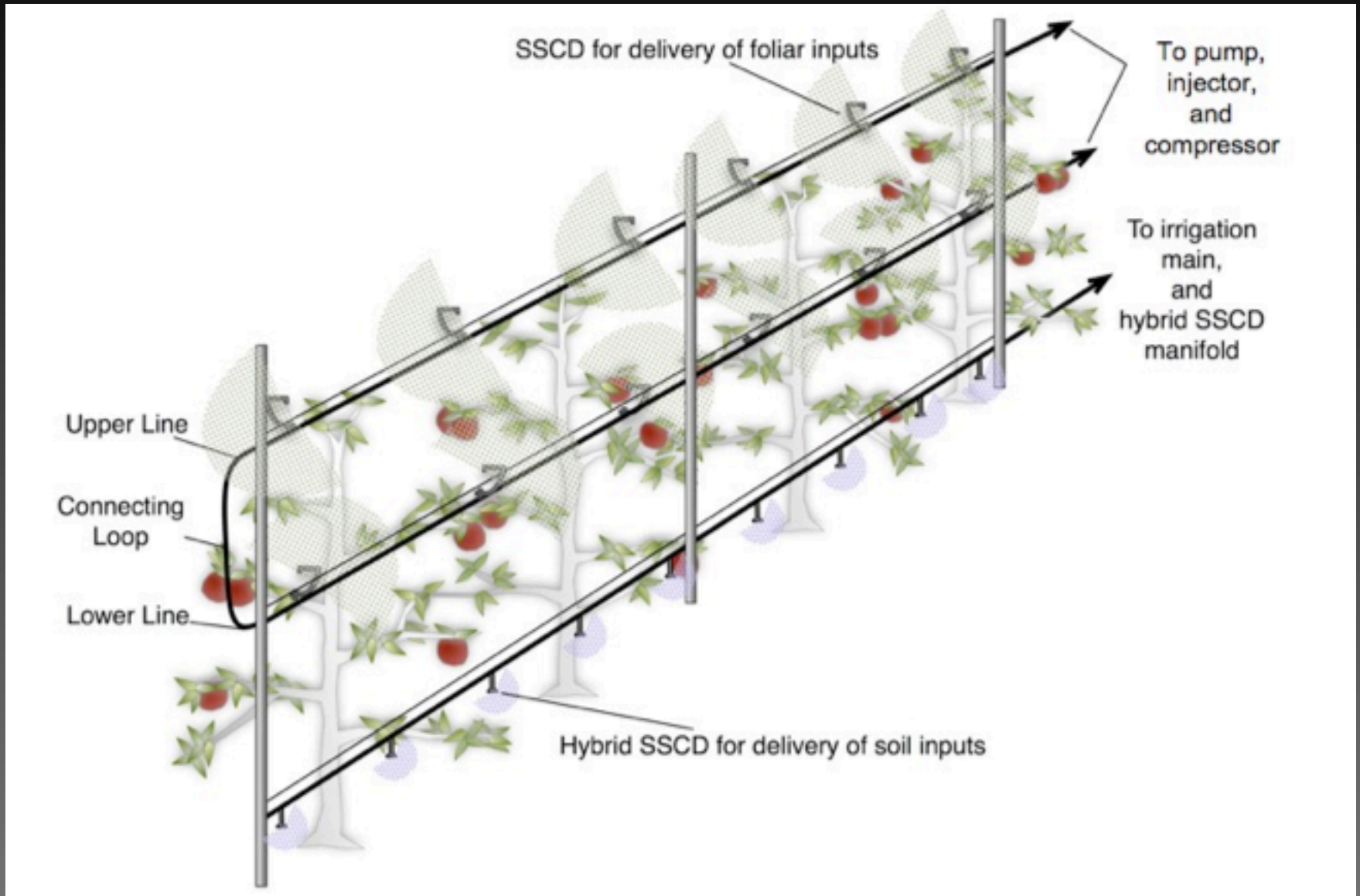
■ Fixed Spray
■ Airblast



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

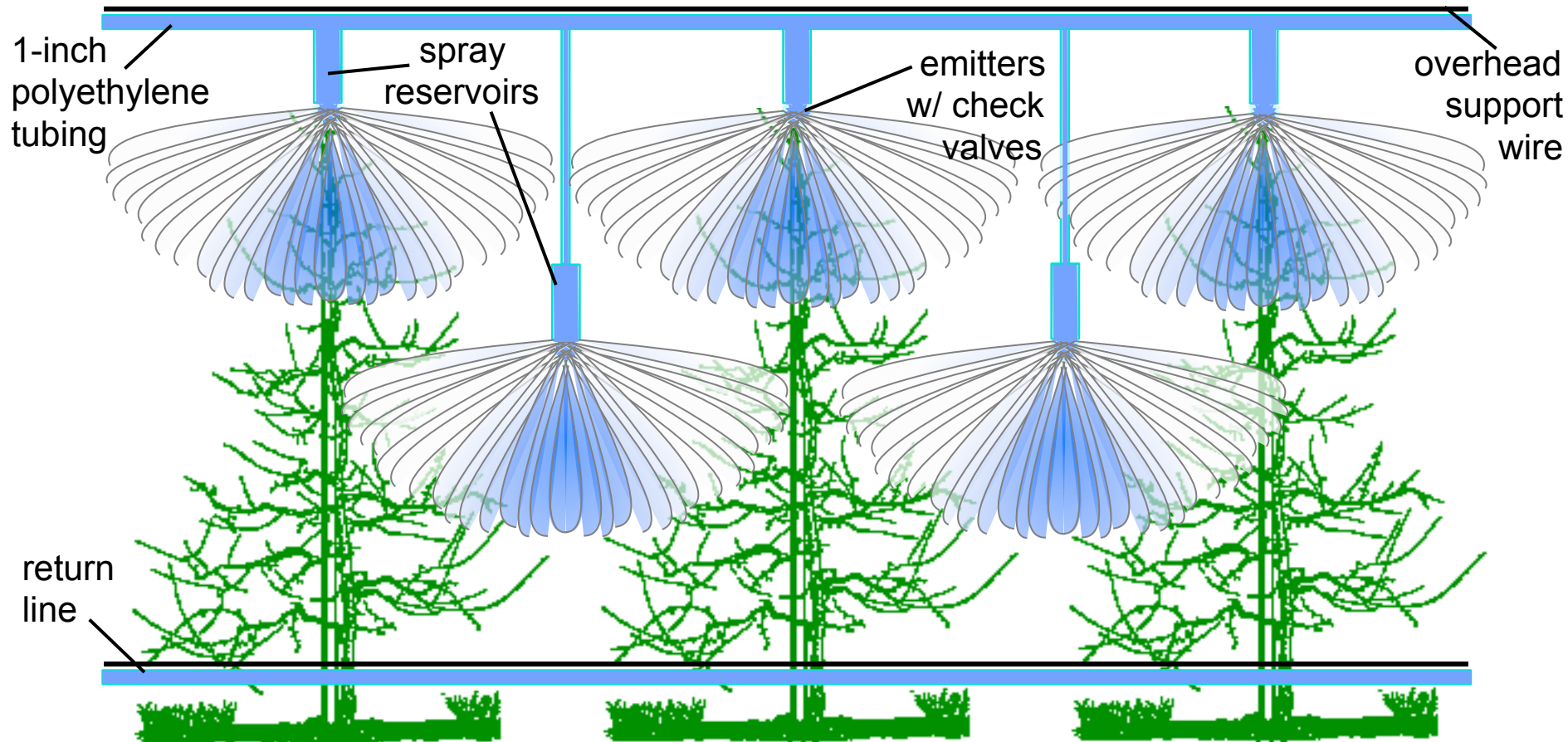
Initial Proposal for Design of Solid-Set Canopy Delivery System



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

Current Design of Solid-Set Canopy Delivery System



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

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