WASHINGTON STATE UNIVERSITY
EXTENSION

Pesticide Application Technology

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Department of Entomology
College of Agricultural, Human & Natural Resources Sciences

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Pesticide Application Technology
(More than Just the Machine & Its Nozzles)

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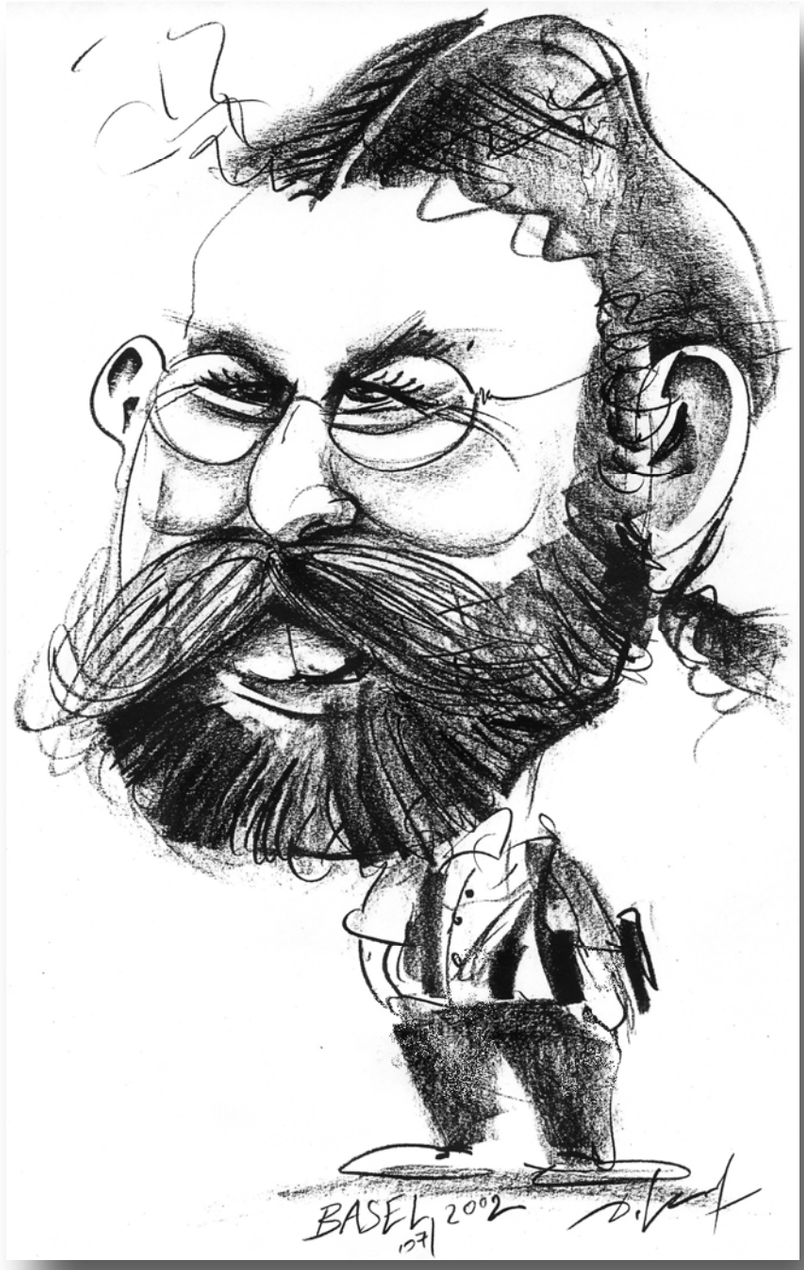
All About Allan

- Subject Matter Expert (SME) Liaison between the Entomological Society of America (ESA) and EPA OPP
- Professor at WSU (1993-present)
  - ✓ Teaching, Extension, Research, Administration
  - ✓ Pesticide technology A-Z
- University of Illinois (1978-1993)
  - ✓ Research, some Extension & Teaching
  - ✓ Environmental chemistry of pesticides; insect toxicology
- Education
  - ✓ PhD (1978) Iowa State Univ. (Entomology)
  - ✓ M.S. (1974) Univ of FL (Entomology)
  - ✓ B.S. (1972) Tulane University (Biology)



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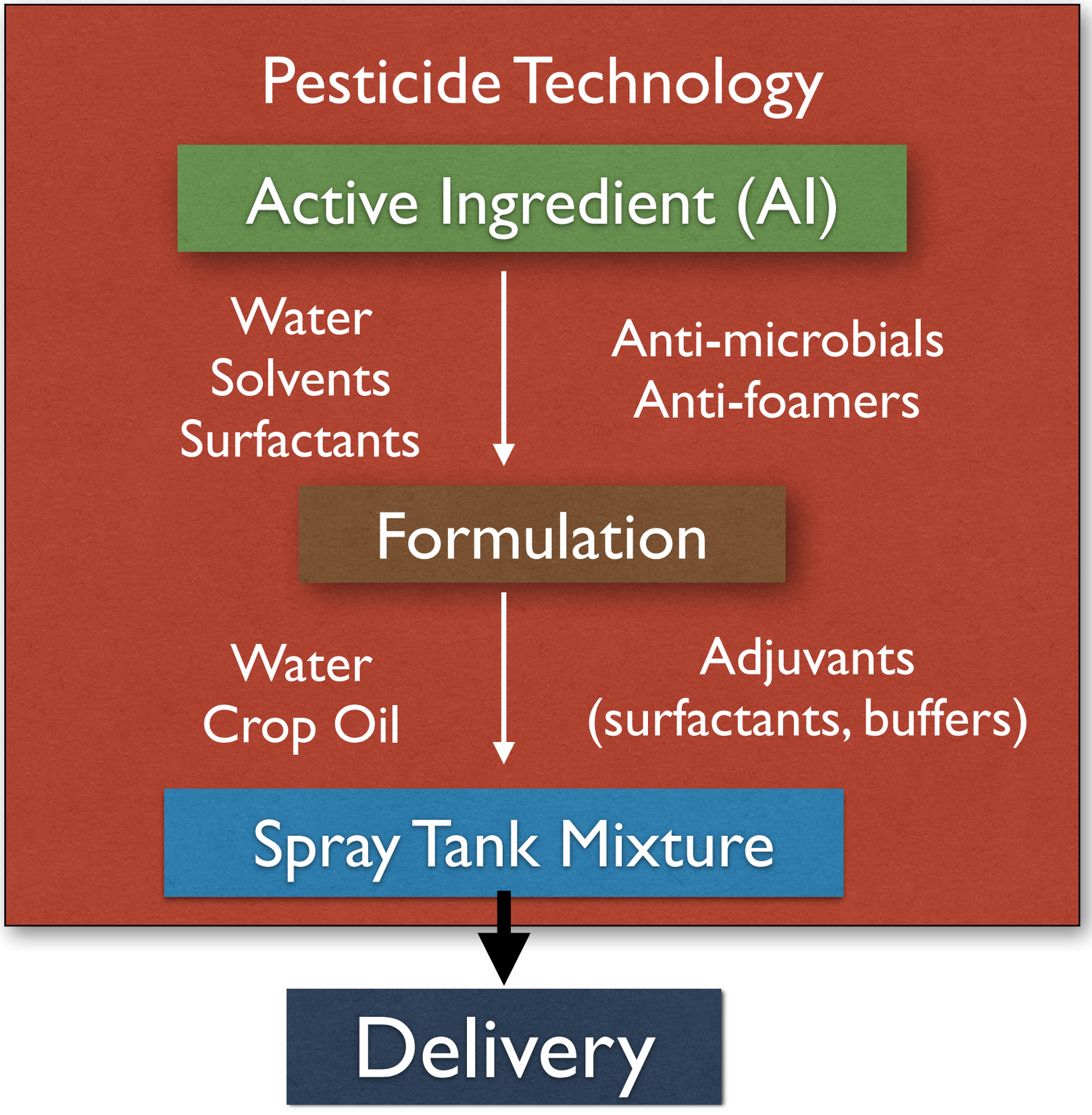
Agenda

- Premise: Pesticide application technology is more than the mechanical technology
- Deconstruction of spraying process
  - ✓ Importance of adjuvants to spray delivery
- The "machines" (spray rigs, granular applicators, and fumigant delivery)
- Importance of how these "machines" are operated
  - ✓ How can machines be operated to reduce "off-target" effects

From Active Ingredient to Residue



Pesticide Application Technology Is More than the Mechanical Technology

- The Machines
  - ✓ Tractor or aircraft "pulling" the sprayer or granular applicator
    - ✳ Includes fumigation technology such as irrigation rigs
  - ✓ Pumps, booms, nozzles
- Chemical Technology
  - ✓ Adjuvants (mostly various types of surfactants)
- Sociological component—the role of the operator
  - ✓ How we choose the appropriate chemical technology and operate the machines in the context of efficacy needs and environmental conditions

The Fate of Pesticide Active Ingredients from Spray to Target & Beyond

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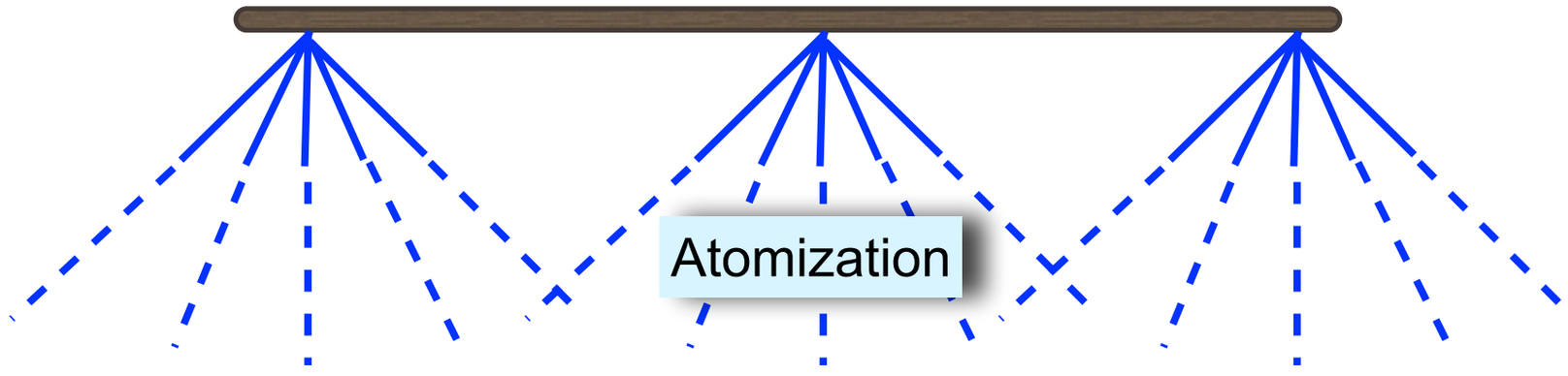

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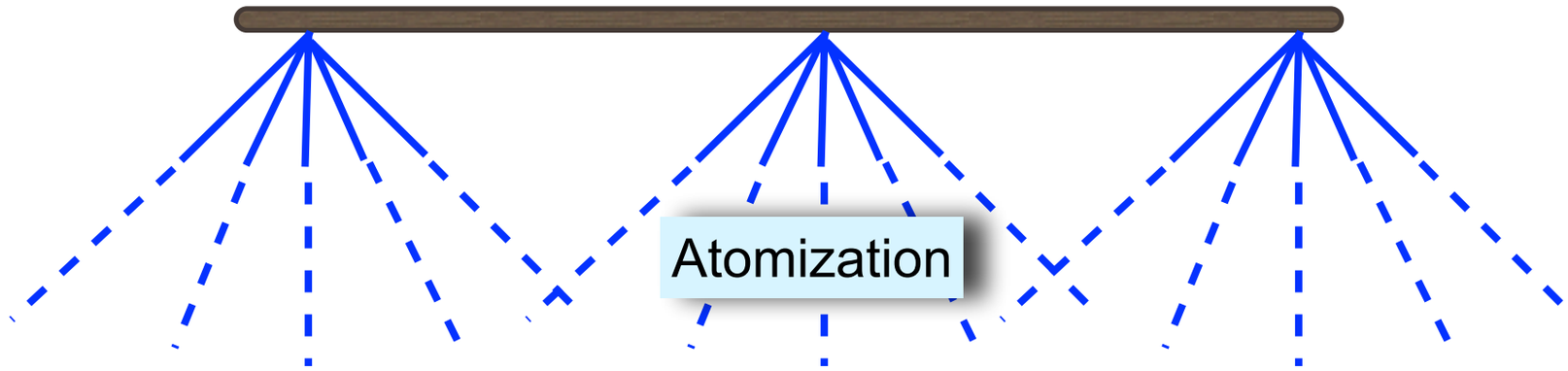

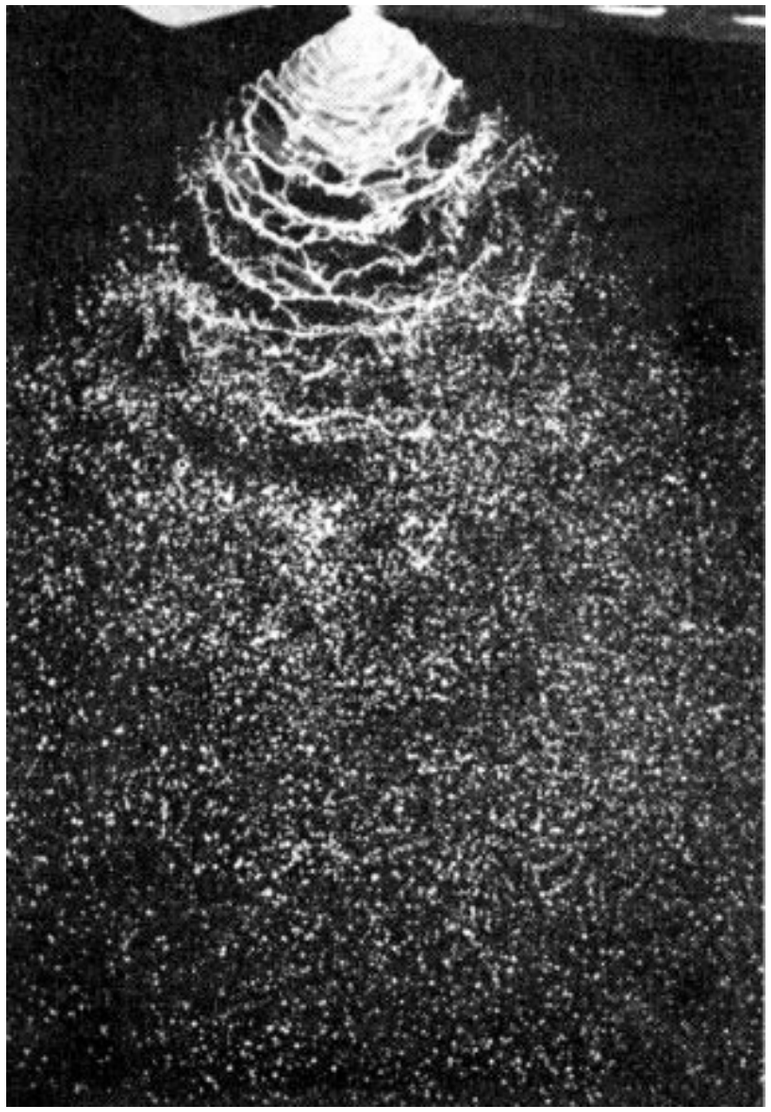

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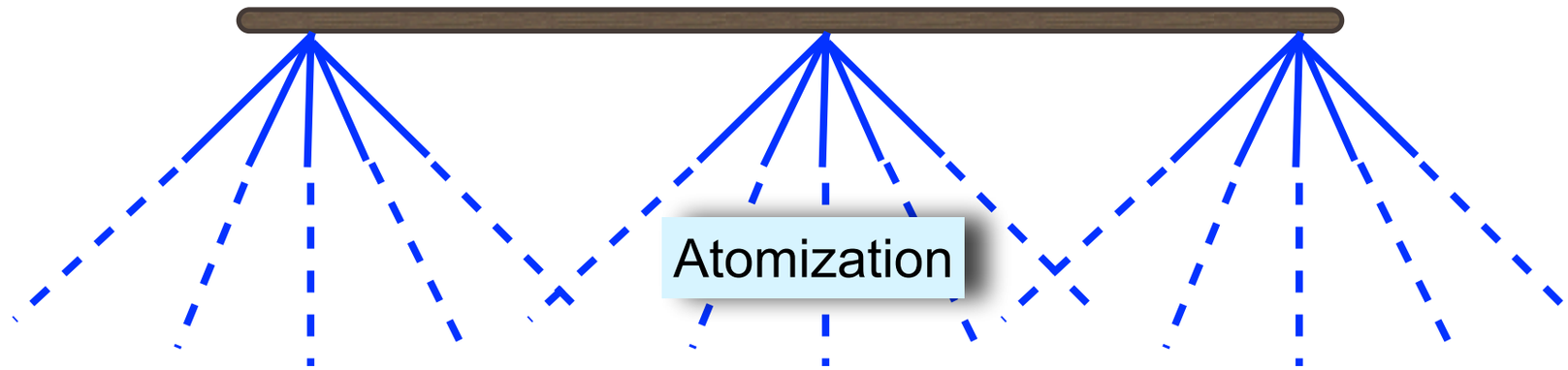
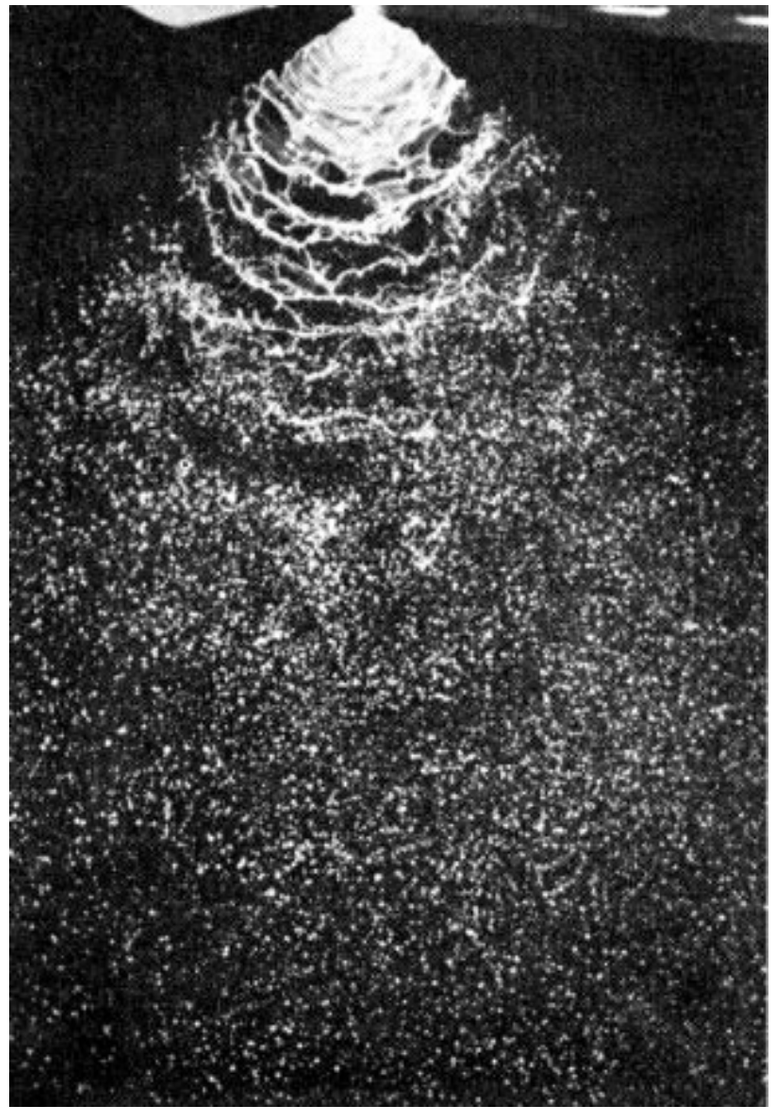
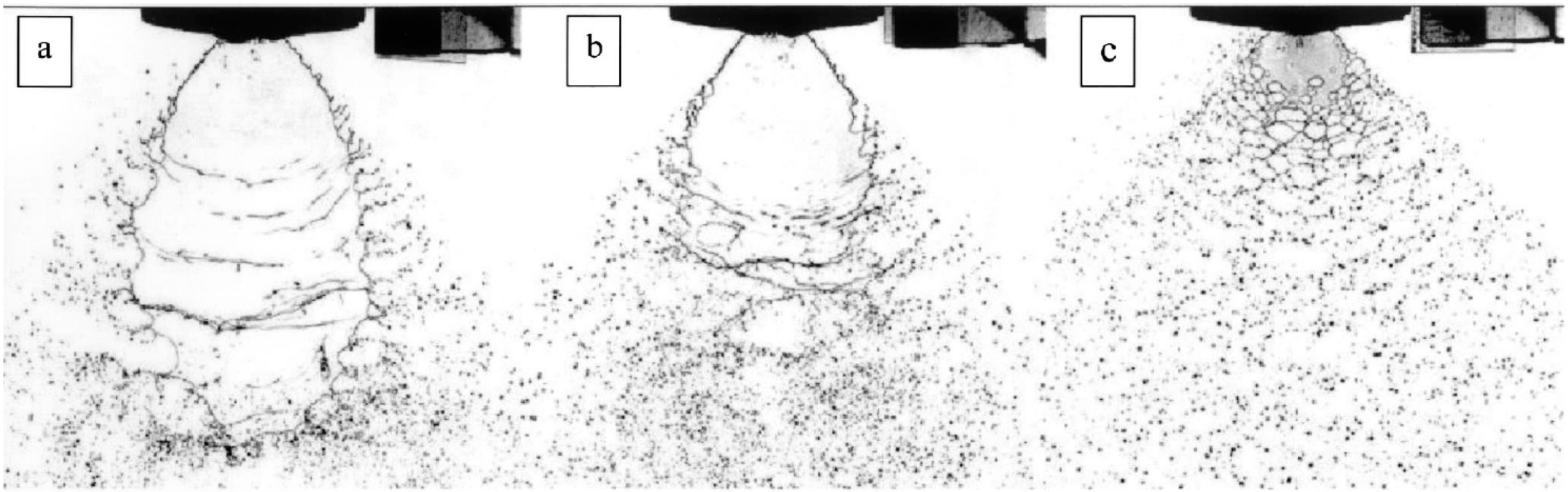


- Solutions are atomized when they flow across a small orifice (i.e., out of the nozzle tip) under high pressure
- They are emitted from the nozzle orifice as a liquid sheet of varying lengths
- The leading edge of the sheet is unstable and breaks apart (shears) into small droplets (atomization process)
- The surface tension and viscosity (resistance to flow) of the liquid can determine how the particles are formed



Effect of Adjuvants on Break Up of Water Sprayed from a Pressurized Nozzle



0.5% Tallow amine Surfactant

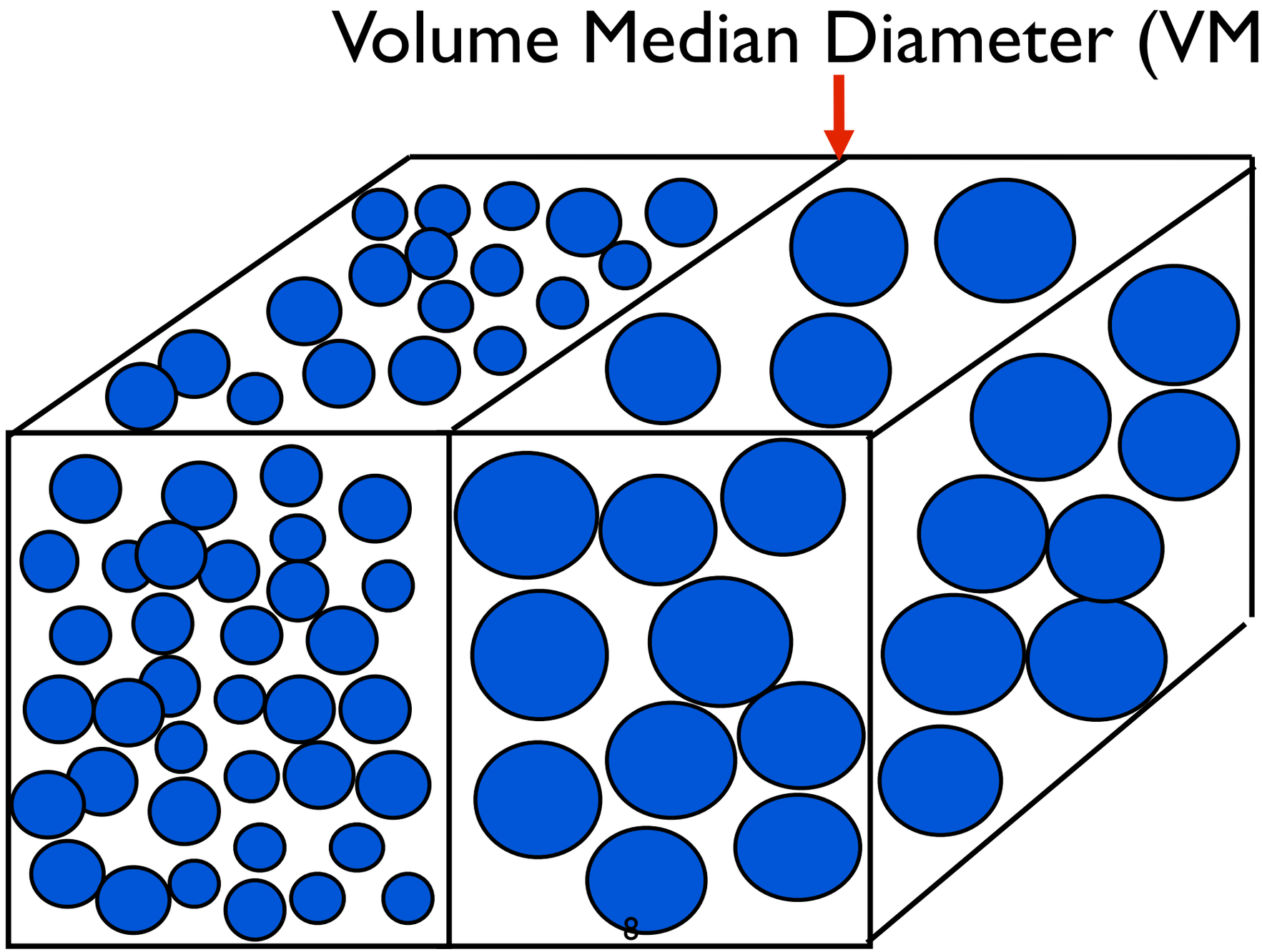
Water Only

1% Vegetable Oil Adjuvant

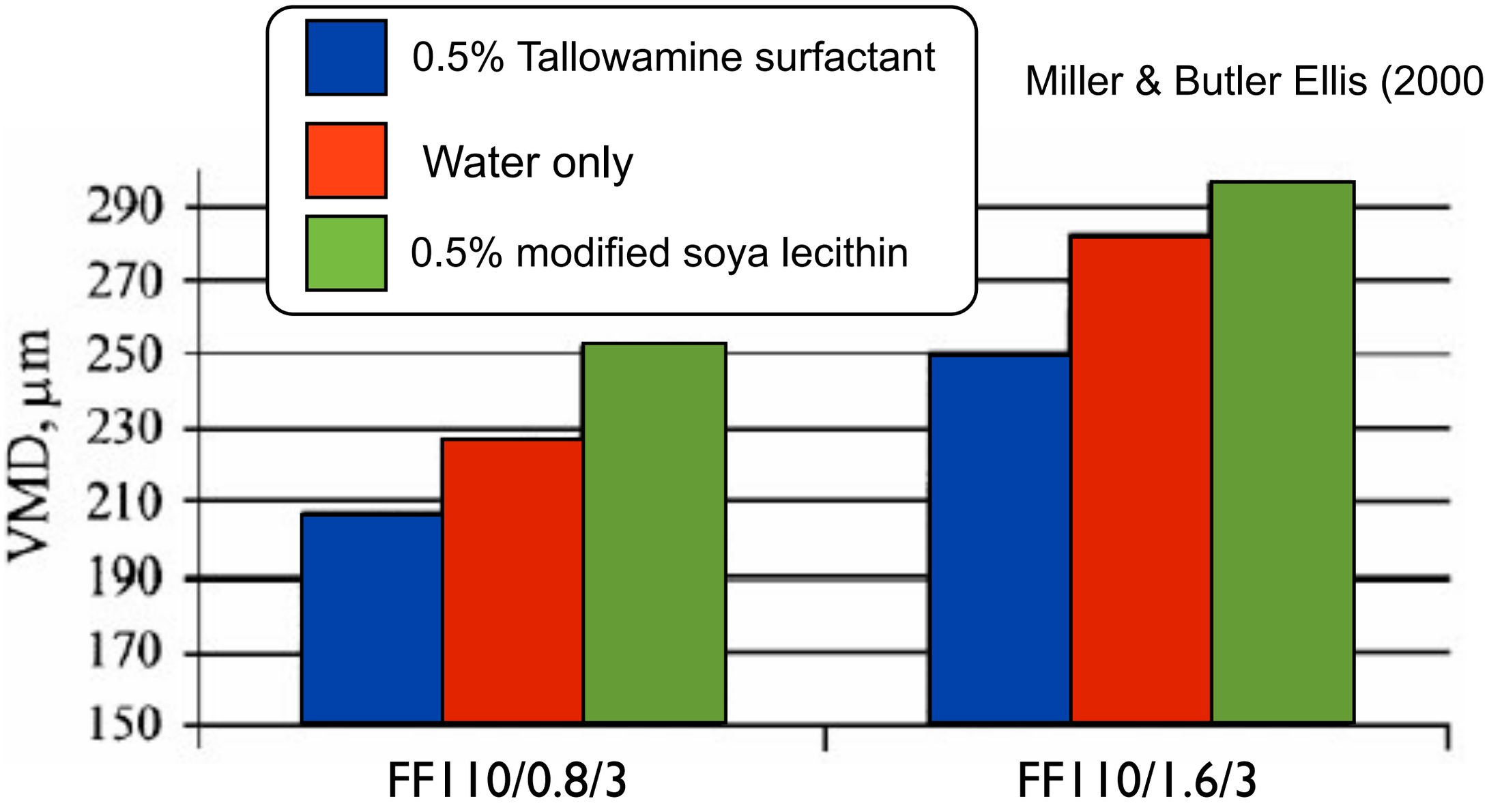
Miller & Butler Ellis (2000)

Expressing Particle Sizes as a Unitary Parameter

- One half of the volume of spray is occupied by particles with spherical diameters larger than the VMD, and one-half of the volume has particles smaller than the VMD

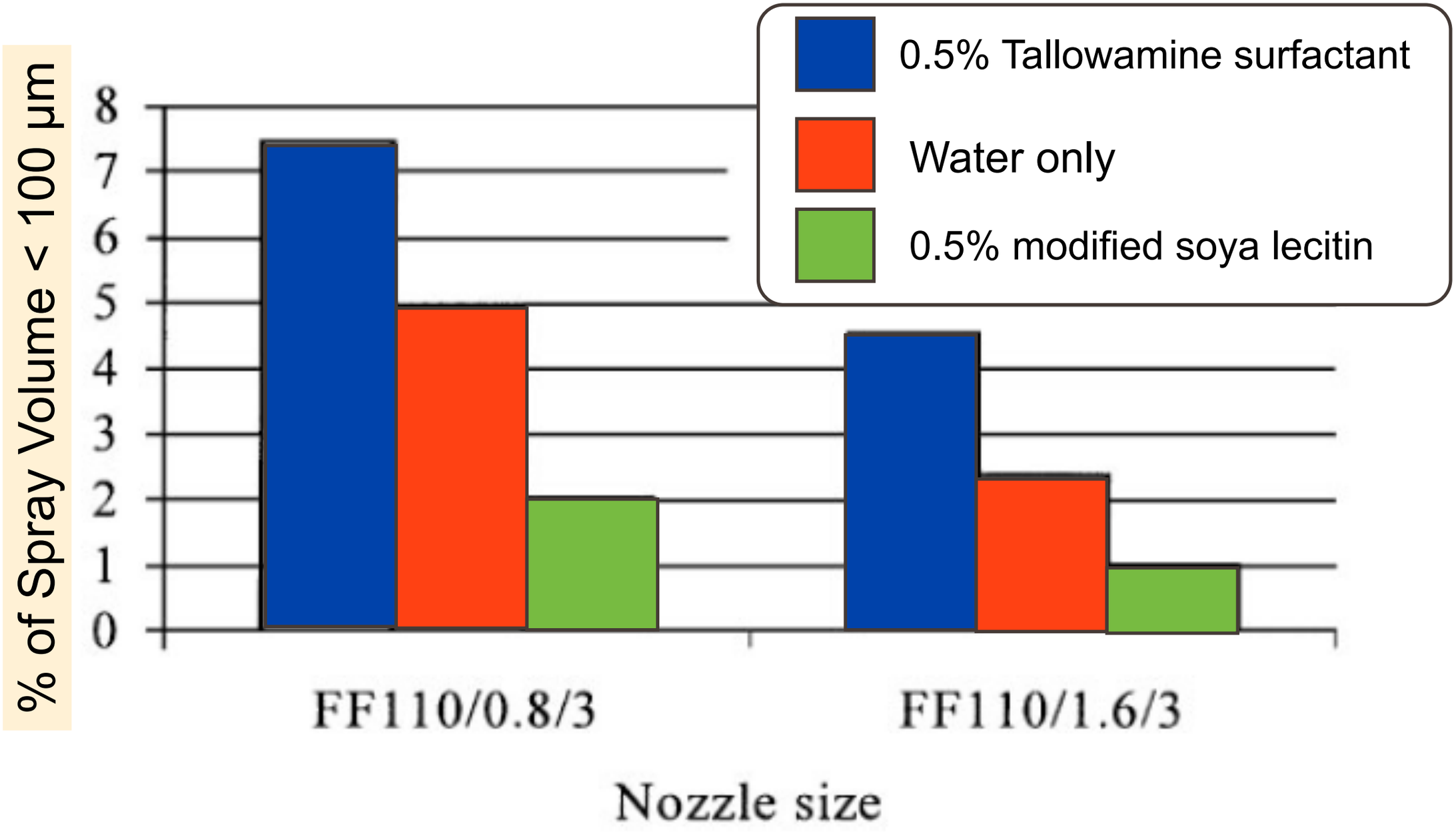


Effect of Adjuvant on Volume Median Diameter (VMD, µm)



VMD: The particle size diameter at which half of the spray volume contains smaller particles and half of the spray volume contains larger particles. For example, if the VMD is 100 µm, than half the spray volume contains particles less than 100 µm.

Percentage of Spray Volume in Spray Particles Less Than 100 µm



Miller & Butler Ellis (2000)

The Fate of Pesticide Active Ingredients from Spray to Target & Beyond

Drift Losses

Transport to Target

Evaporation

Impaction on Target

Retention

Spreading

Drying

Reflection
(Bounce-Off)

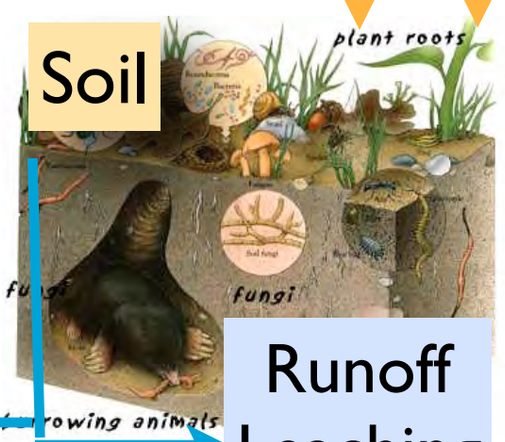
Deposit Formation

Movement in/on Plant

Diffusion into Animal

Biological Effect

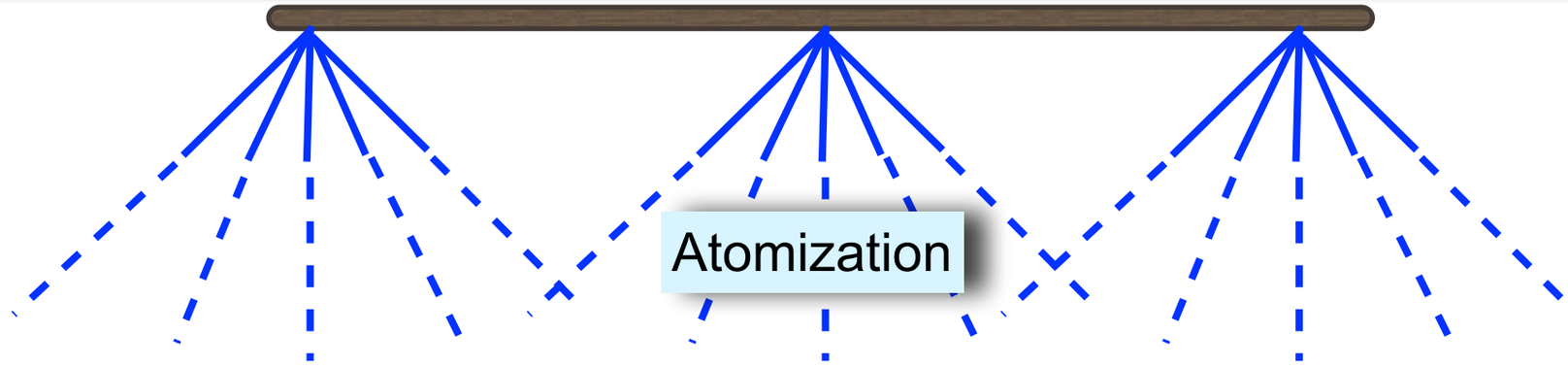
Washoff
Photodegradation
Metabolism
Root Exudation



Volatilization

Runoff
Leaching

The Fate of Pesticide Active Ingredients from Spray to Target & Beyond



Atomization

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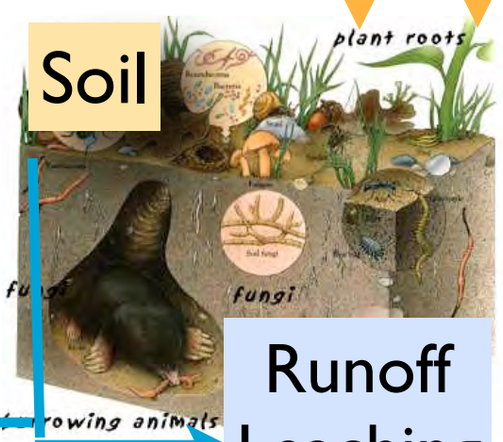

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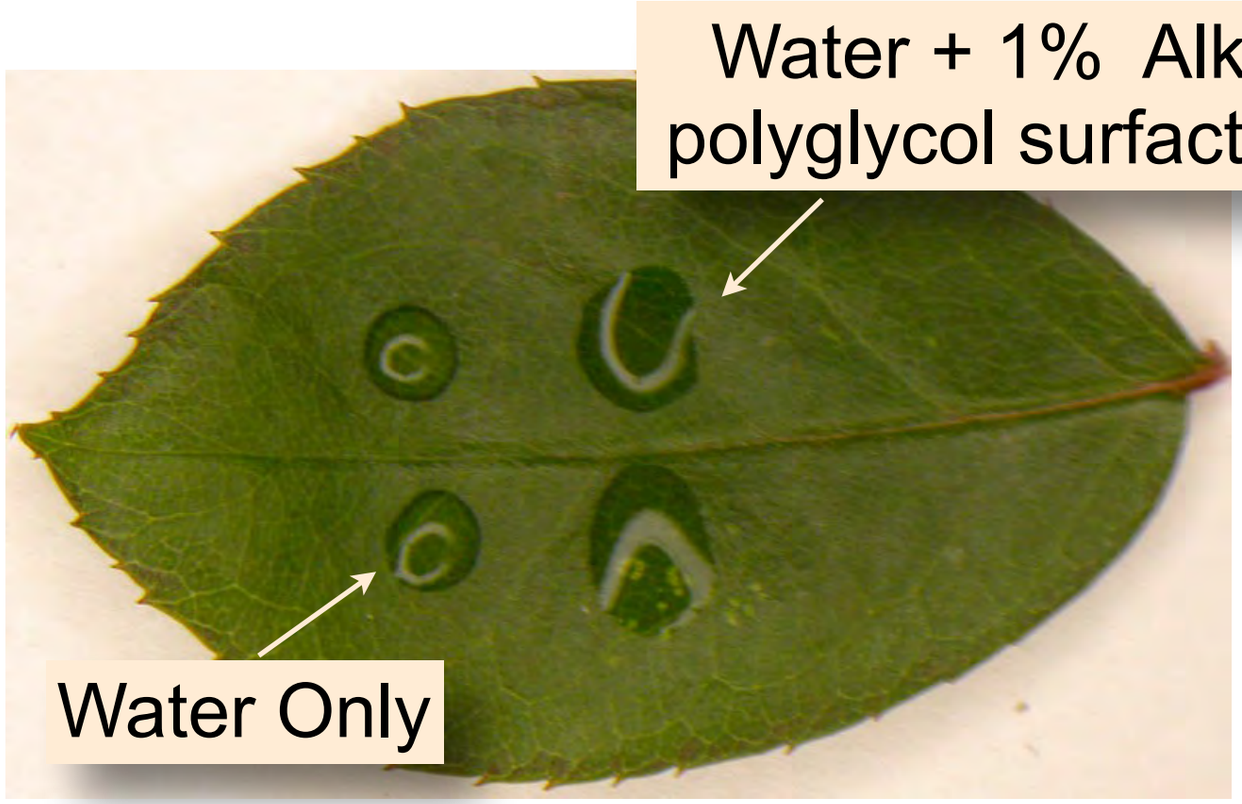
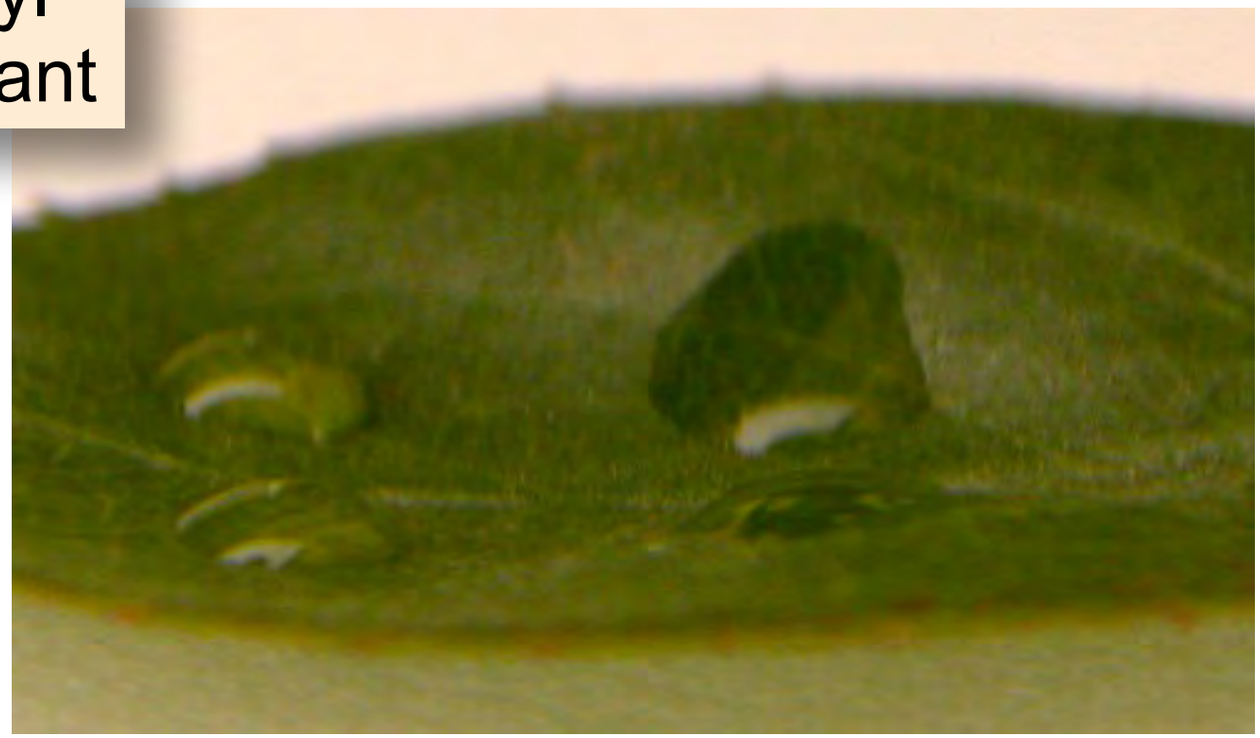
Why We Need "Other Ingredients" to Achieve Efficacy in the Field

- If modify surface tension, water droplet will spread over the surface

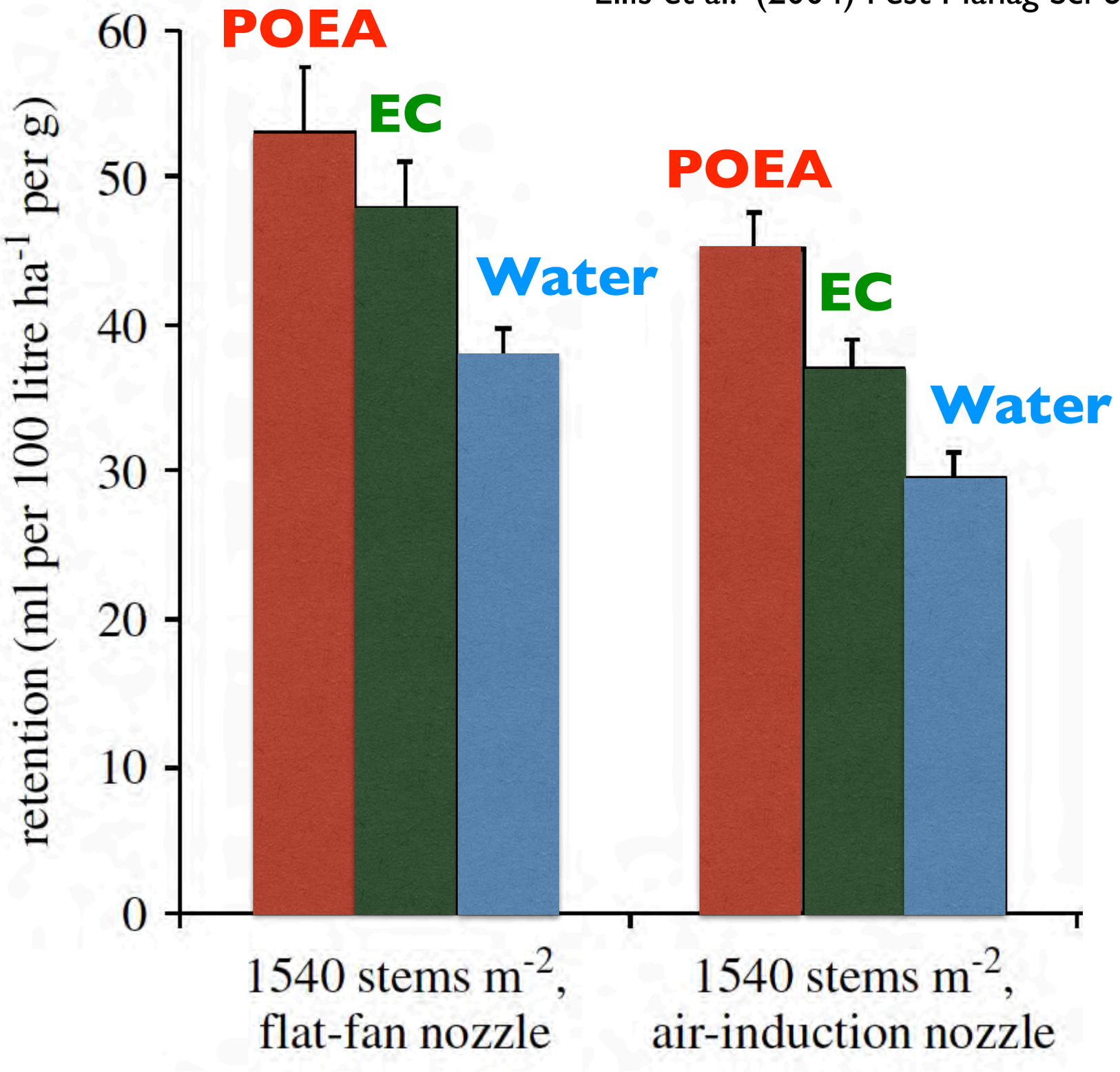




Adjuvants Can **Enhance Retention** of Spray Droplets on Leaf Surfaces

Ellis et al. (2004) Pest Manag Sci 60:786–794

Retention on Wheat Leaves



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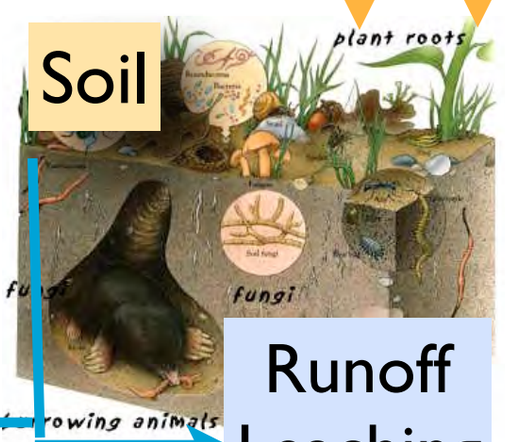

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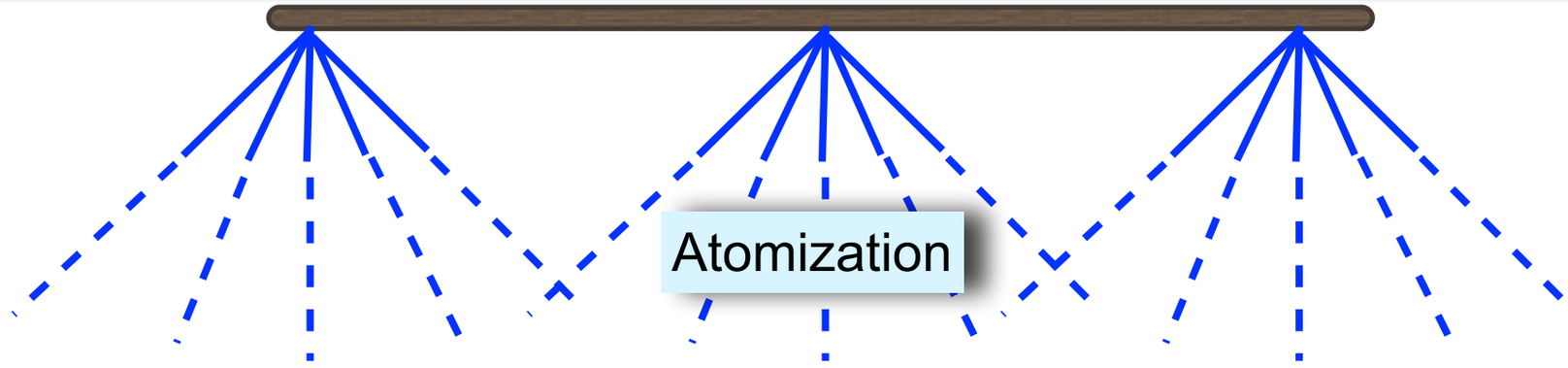

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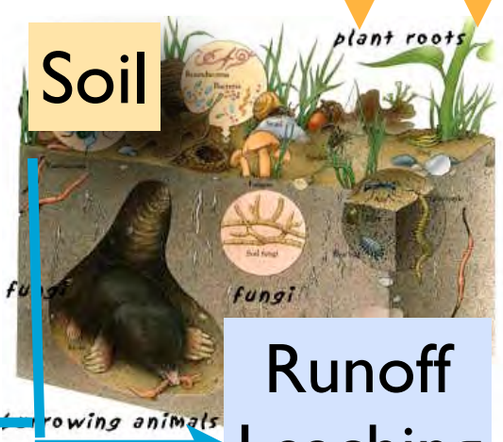
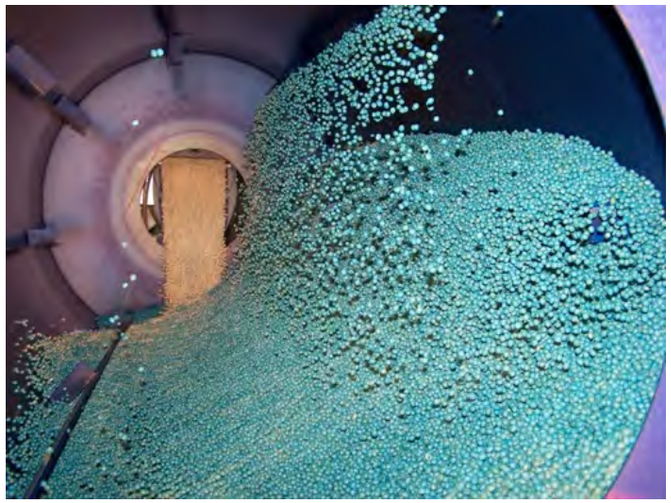


Volatilization

Runoff
Leaching

Types of Application Techniques

- Foliar & soil spraying of liquid formulations in water or oil
- Soil application of granular formulations
- Seed treatments
- Fumigation of soil or a ‘space’
- Dispensers containing pheromones
- Barrier devices



Objectives of Application from an Efficacy Perspective

- Place the spray or granular formulation where the pest is or will be
- Successful control will depend on good coverage of the surface intended to receive the spray
- Some pesticides are mobile within the plant or across the leaf surface

Visualization of Spray Deposition with Dayglo Paint Under UV Light

Using Liquid Spraying as the Model

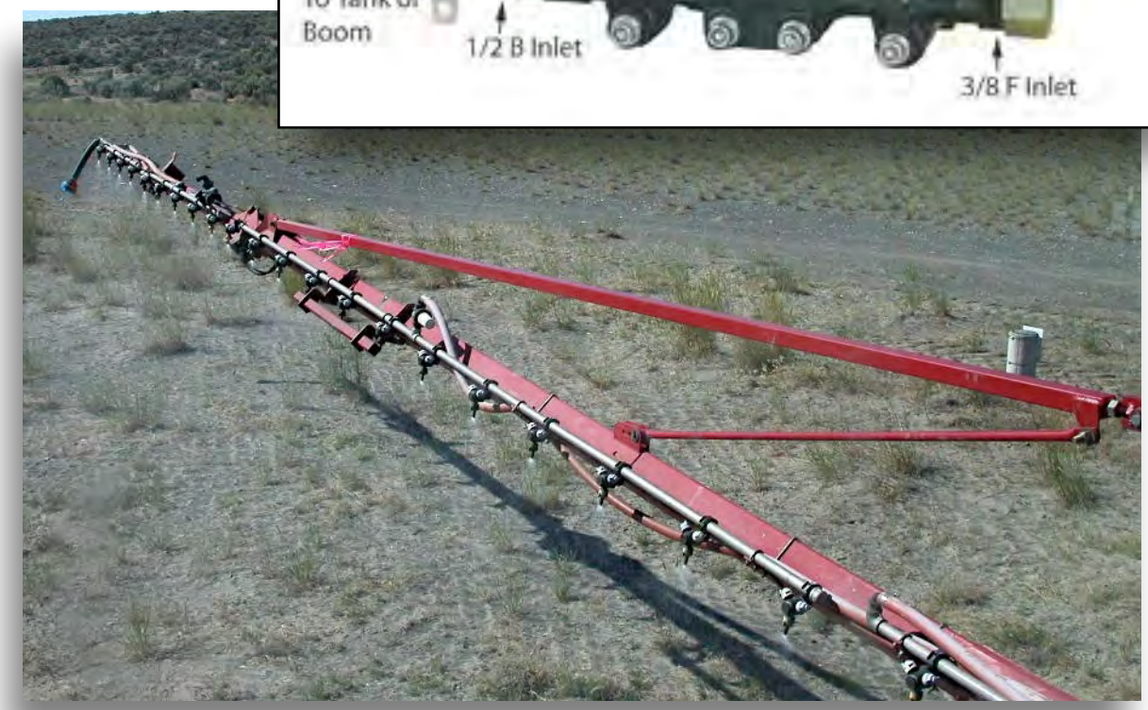
- Pieces of equipment

  ✓ Spray tank (reservoir)

  ✓ Pump

  ✓ Hose & boom

✓ Nozzle



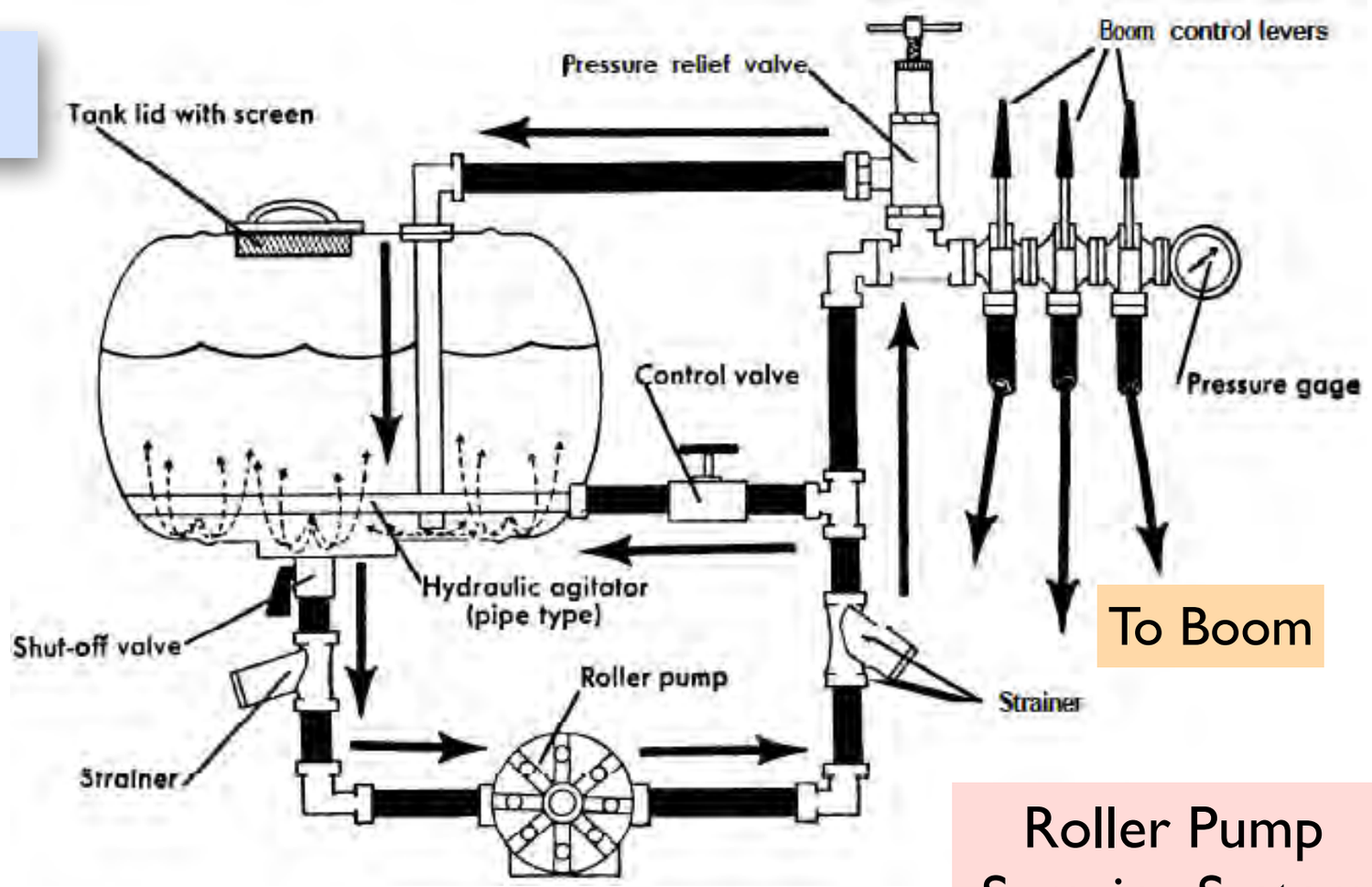
Basics of Pumping Systems

- Consider that the spray tank will be holding pesticide active ingredients in a formulation diluted in water

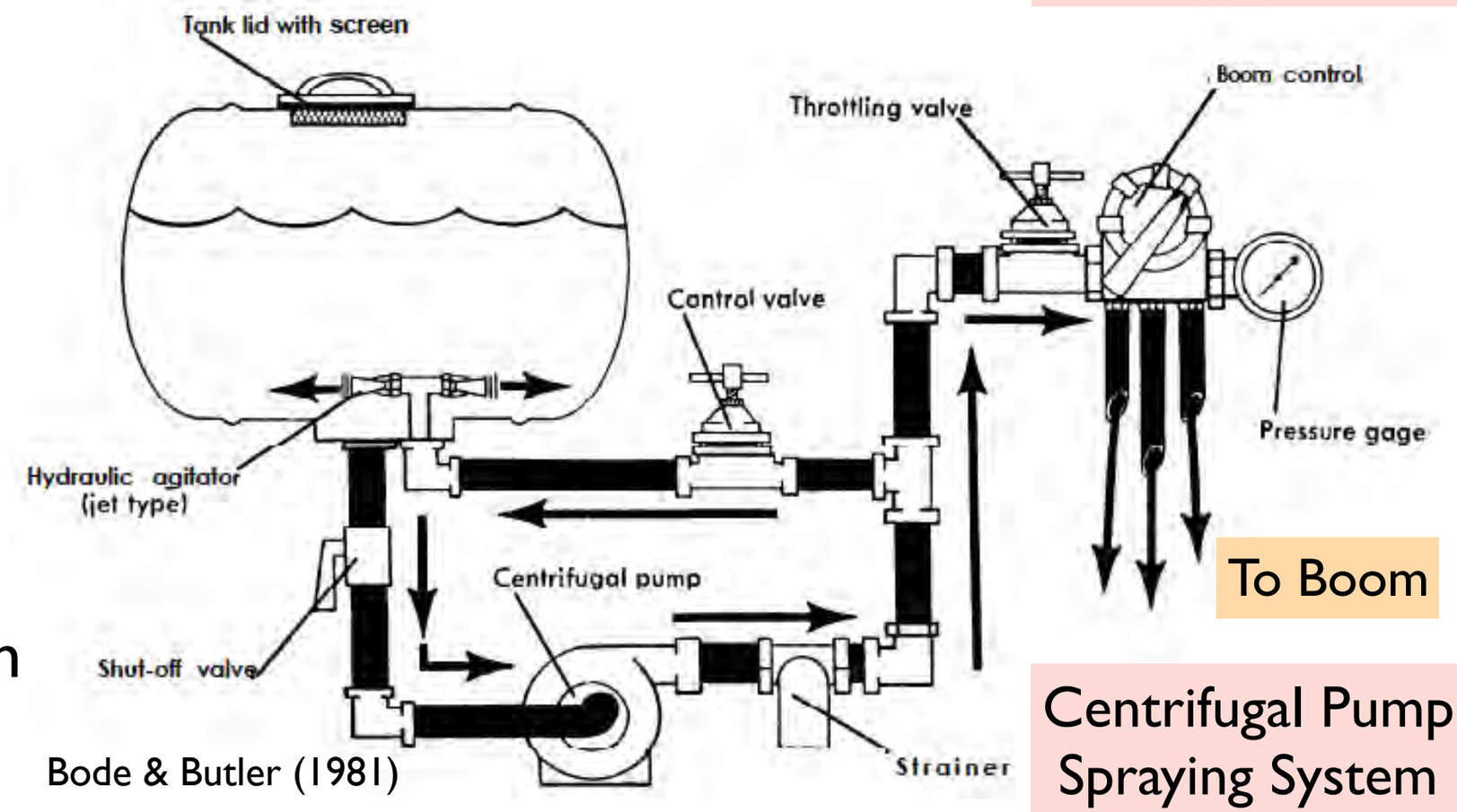
  ✓ Owing to the different properties and densities of the materials, it is important that the tank contents be well mixed prior to delivery to the boom

  ✳ Especially important when using wettable powder formulations

  ✓ The pump is key to both mixing and delivery



Roller Pump Spraying System



Bode & Butler (1981)

Centrifugal Pump Spraying System

End of the Line: The Nozzle

- The liquid spray is pumped under pressure through a network of hoses connecting to a boom that supports pipes terminated periodically with nozzles

  ✓ A nozzle is functionally the end of a pipe through which liquid emerges as a jet

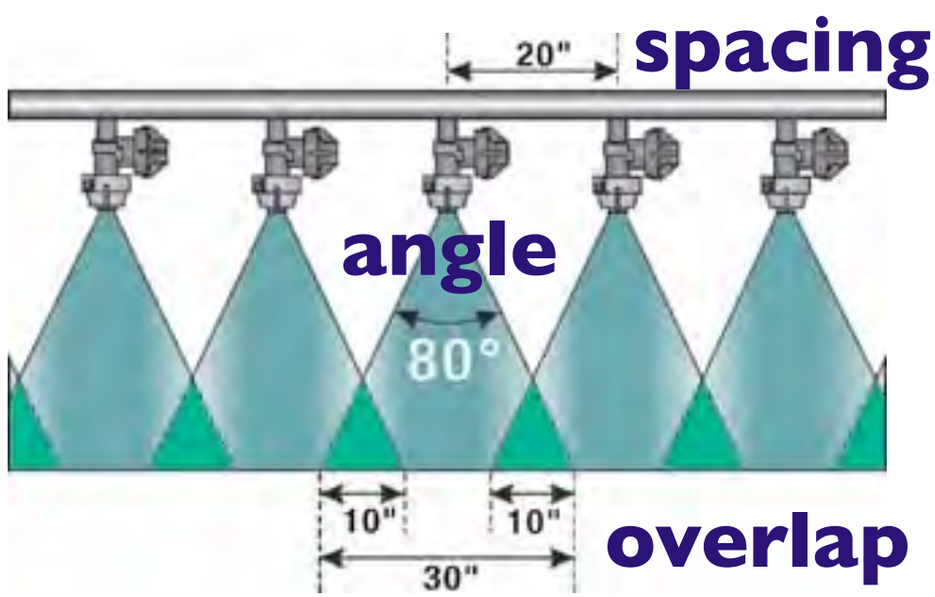
  ✓ In other words, a nozzle is any device through which spray liquid is emitted, broken up into droplets and dispersed at least over a short distance

    ✳ Further distribution of spray droplets is influenced principally by natural air movements

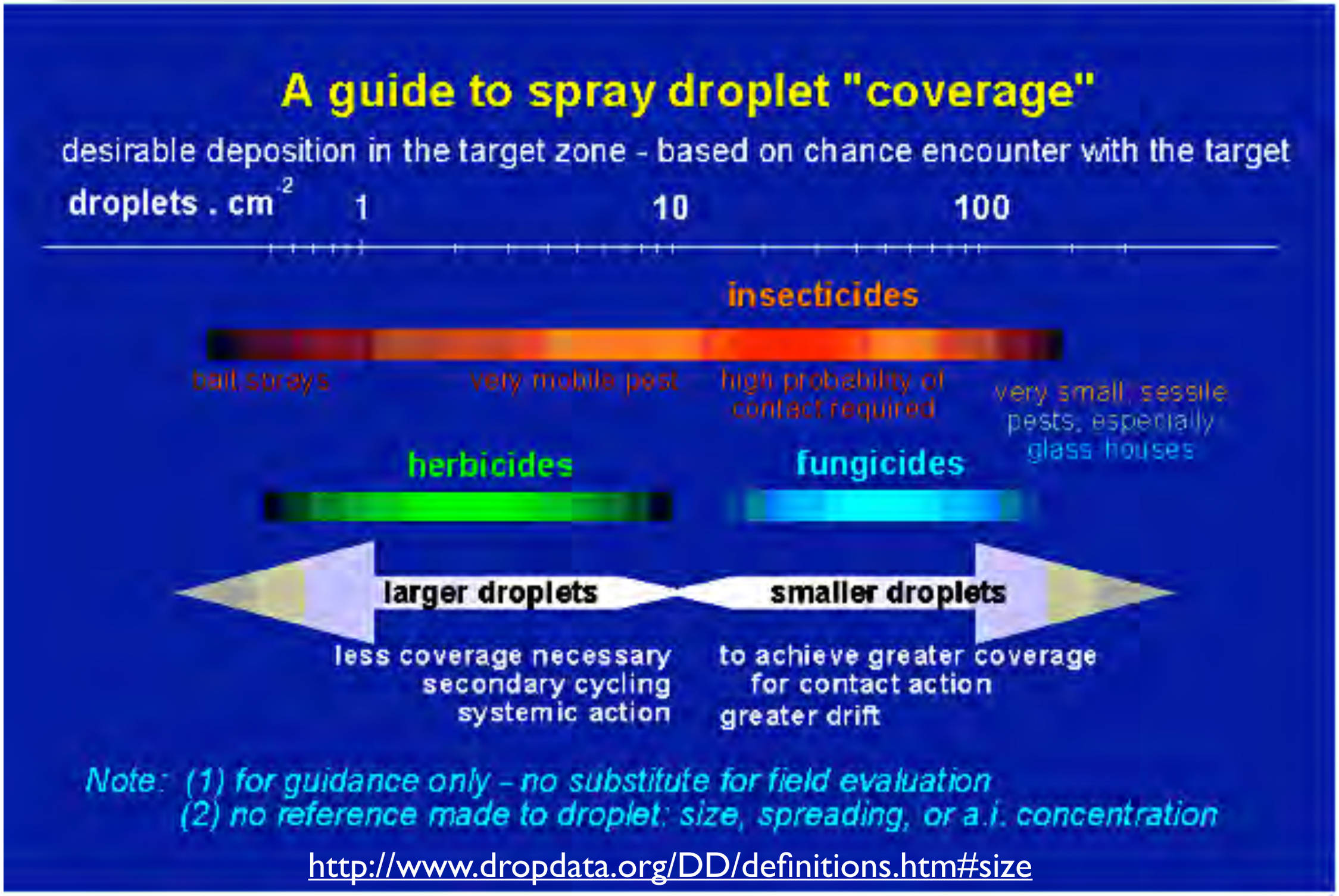
    ✳ Some sprayers use an airstream to direct the spray toward its target

- Nozzles regulate spray flow rate (pressure also important), spray angle and coverage, and in part drift away from target

Note spray angle, nozzle spacing, and overlap of spray pattern



Optimal Droplet Size Varies by Context of Use



http://www.dropdata.org/DD/definitions.htm#size

Coverage is defined as the extent to which a pesticidal spray has been distributed on a target surface. The biological implication is that good coverage increases the probability that a pest will encounter a pesticide.

Sprayer Equipment: Aerial Application

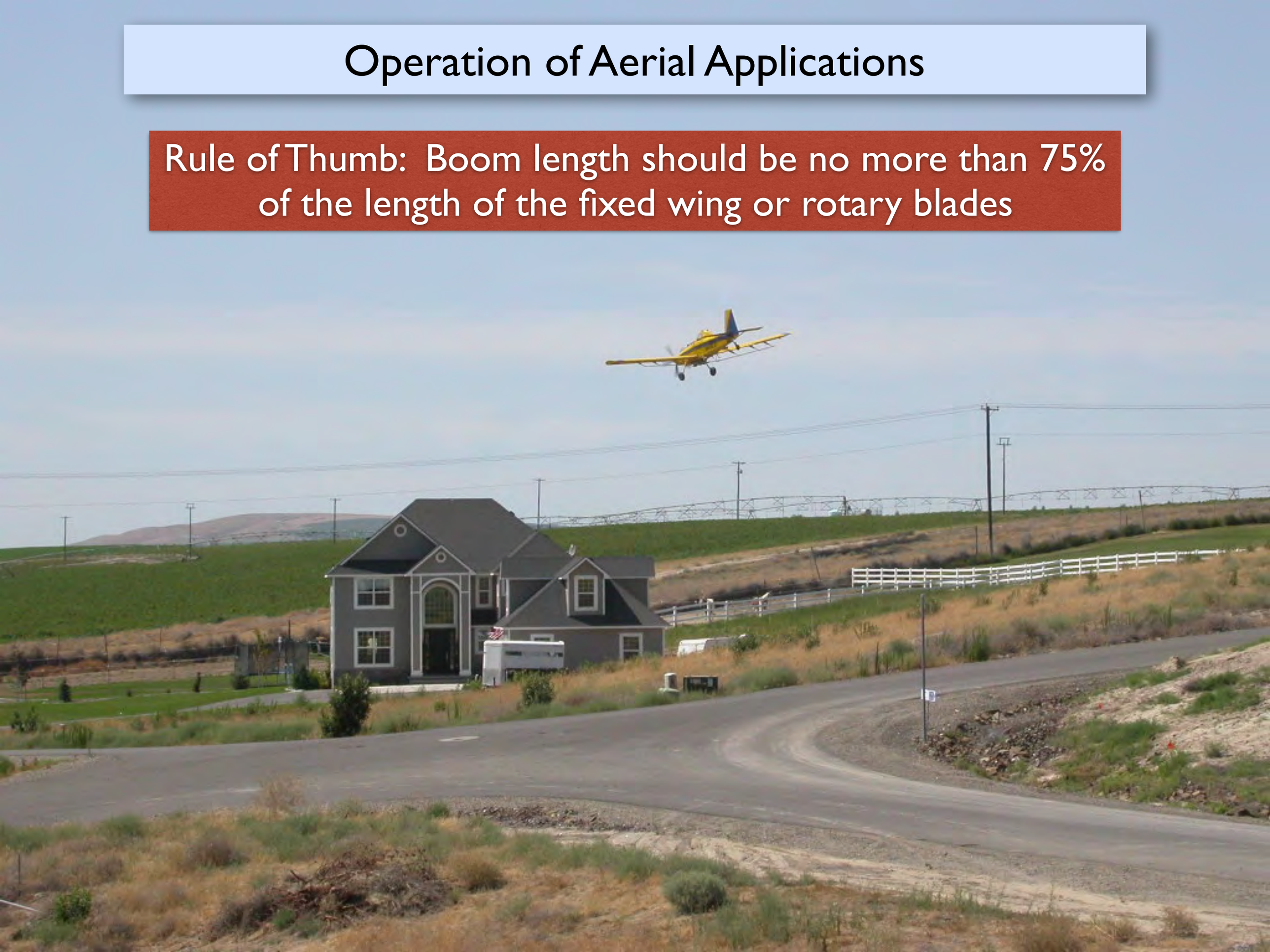
Fixed Wing

Rotary Wing

Typical Uses: Grain & Vegetable Crops; Forestry

Operation of Aerial Applications

Rule of Thumb: Boom length should be no more than 75% of the length of the fixed wing or rotary blades



How Aerial Spraying Is Supposed to Be

Operator Error?

So Far, So Good

Looks Like the Pilot Is Watching those Telephone Lines

Looks Like the Pilot Is Watching those Telephone Lines

What's Wrong with this Picture?

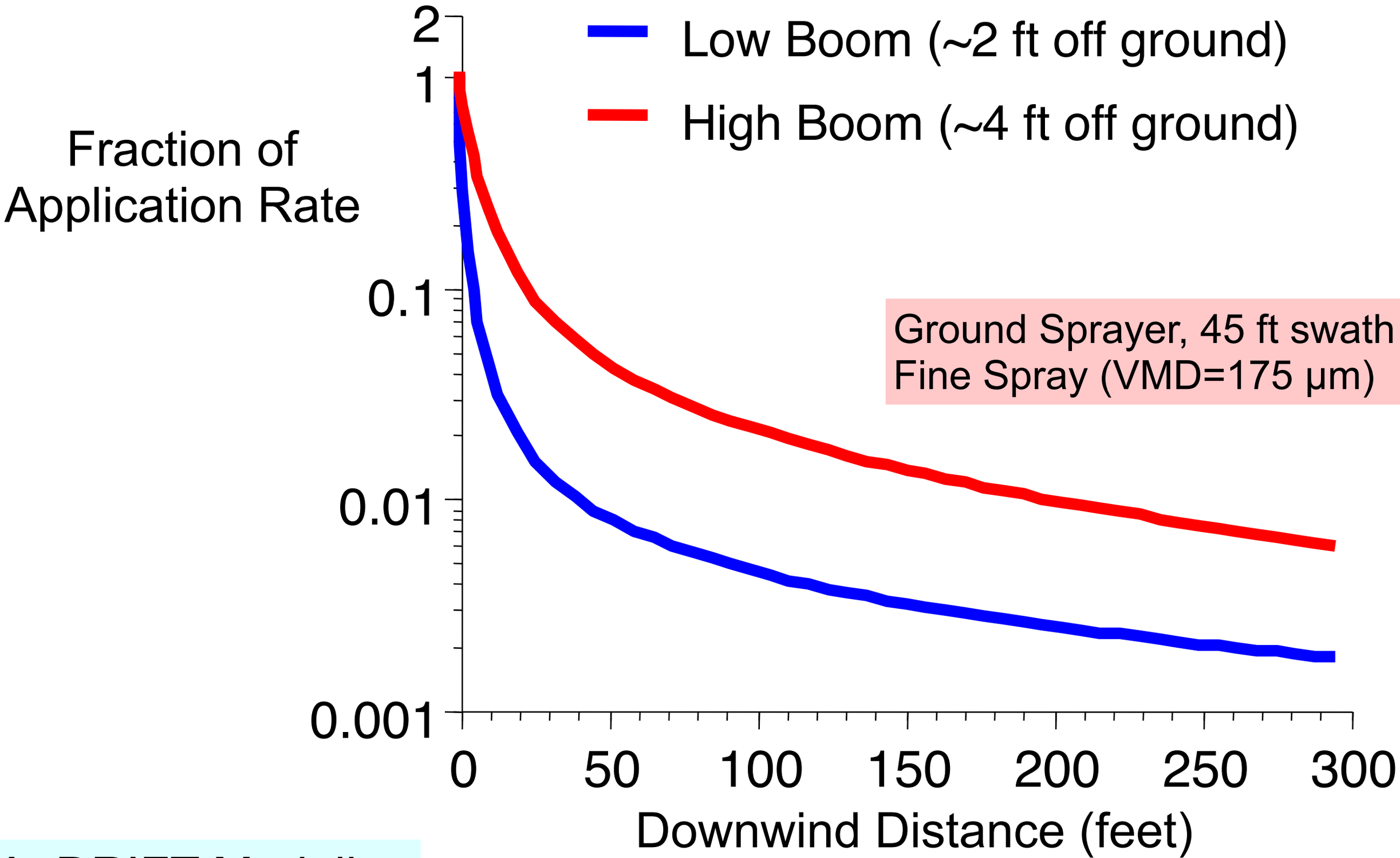
The Drones Are Coming

The Drones Are Coming

Spray Equipment: Ground Application

Ground Booms:
Typical Applications on grain & vegetables

Effect of Boom Height on Downwind Drift Deposition



Ground Sprayer, 45 ft swath
Fine Spray (VMD=175 µm)

AgDRIFT Modeling

Ground Sprayer Technology to Manage Drift Out of Field

- Drift: Downwind movement of airborne spray droplets beyond the intended area of application originating from aerial or ground-based spraying operations

Boom Shields

Air Induction Booms

Application of Soil Insecticides

(An Old Market Making a Comeback Due to Corn Rootworm Resistance to Bt Corn)

Granular soil insecticides are incorporated into an ~7-inch band over the seed row

How the Planter with Soil Insecticide Delivery Works

- When the top of the hopper box is closed, the tank and the hoses become pressurized; just like if you capped a straw with your finger

  ✓ The pressure causes seeds to "blow" into individual row units. This is the piece of the planter that will put the seed in the ground.

- Each row unit has its own hose (#1) that links it to the main hopper tanks. Once seeds fill the smaller hopper boxes (#2), gravity forces them into the meter.

- Inside each meter (#3), a seed is sucked onto a plate that is pocked with individual holes. One seed to one hole. The vacuum effect is what holds the seed to the plate.

- As the planter moves through the field, the row cleaners (#4) push stalks, leaves and clods of dirt out of what will become the furrow.

- Gauge wheels (#5) regulate how deep a seed will be planted. The silver discs (#6) are "openers" that open the soil to create the furrow. The seed meter continually spins dropping one seed into the ground at a time.

The Soil Insecticide Smart Box as an Example of Closed Application System Equipment

Boom Sprayers for Cultivating and Spraying

Hagie™ Self-Propelled Sprayer

Sprayer Equipment: Orchards & Vineyards

- For insect and disease management in orchards and vineyards, basically two types of sprayers are used

✓ Air-blast

✴ Spray emitted from from nozzles located several feet off the ground

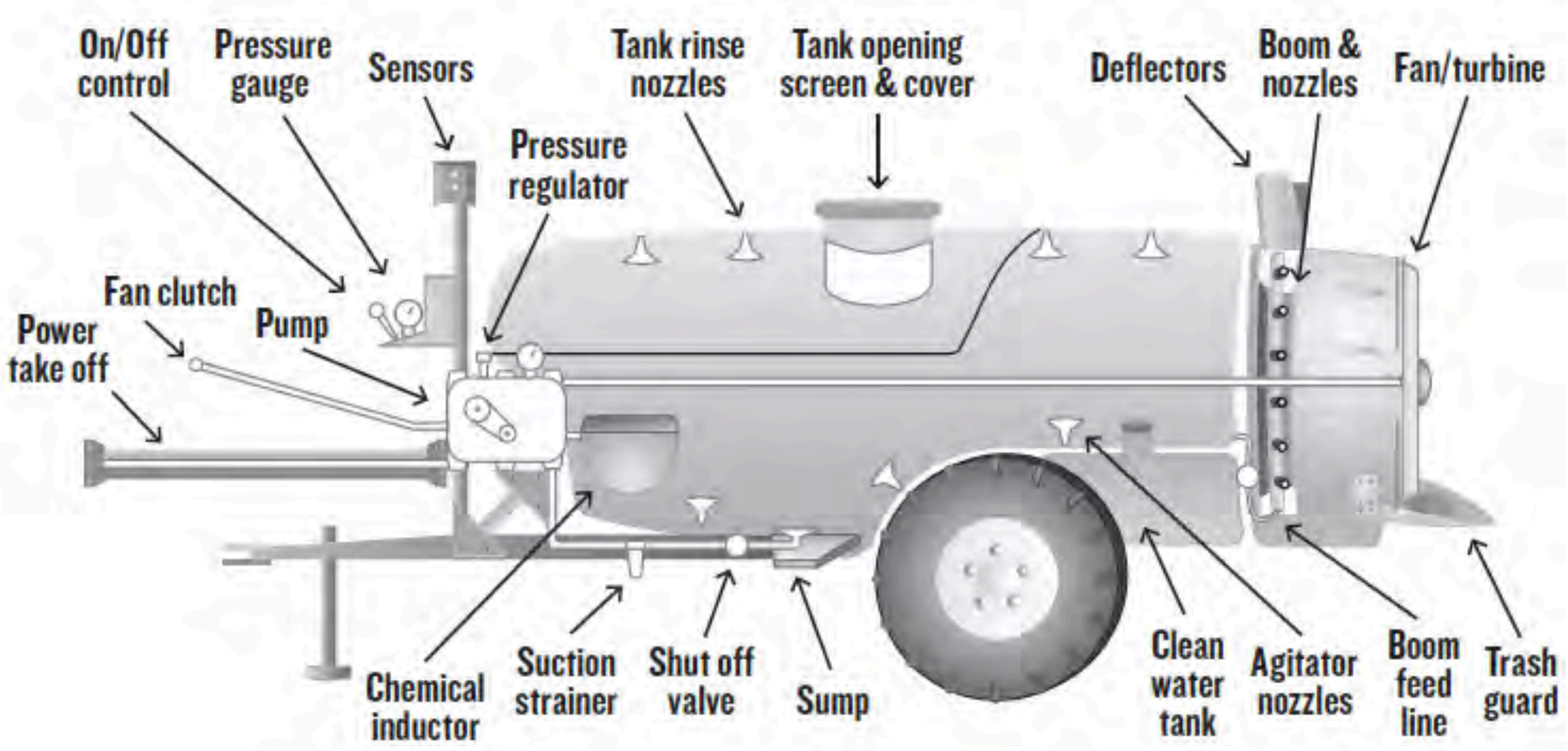
✴ Spray emitted from towers that run parallel to the tree height

✓ Proptec

✴ Spray delivered is delivered through a hose that is broken up by a fan pushing air over the hose end nozzle

✴ Consists of series of fans situated parallel to the length of the tree

Airblast Sprayers: The Most Used Machines for Orchards & Vineyards



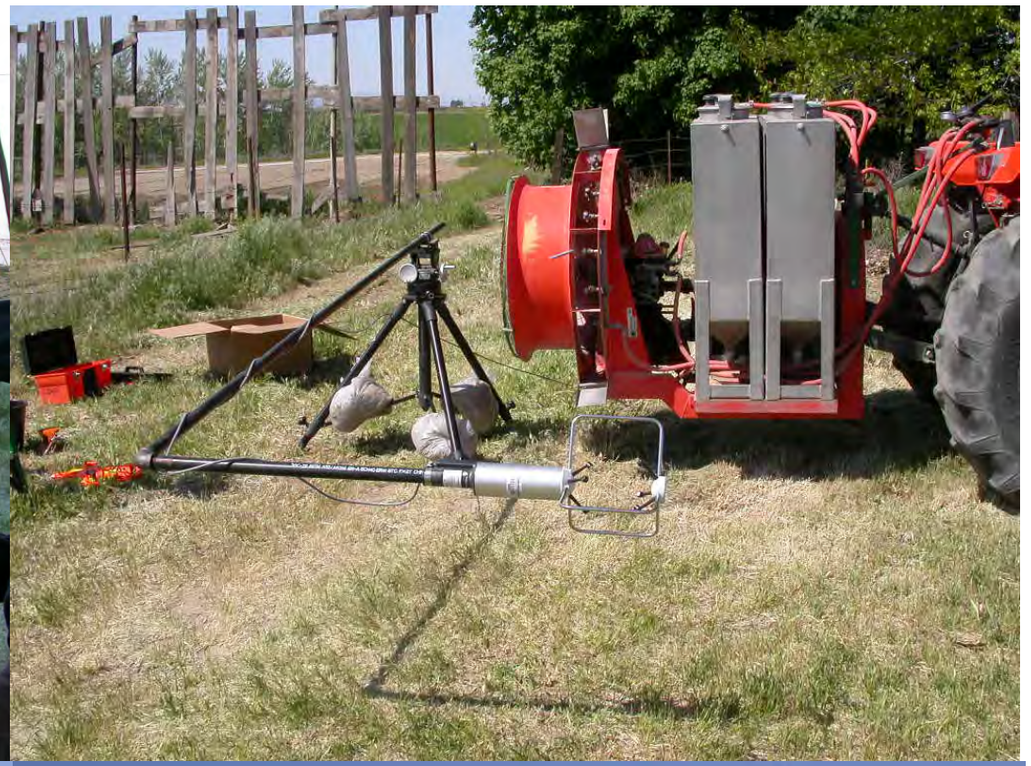
Sprayer Equipment: Orchards & Vineyards

Axial Fan Air-blast Sprayers; Typical Use in Orchards

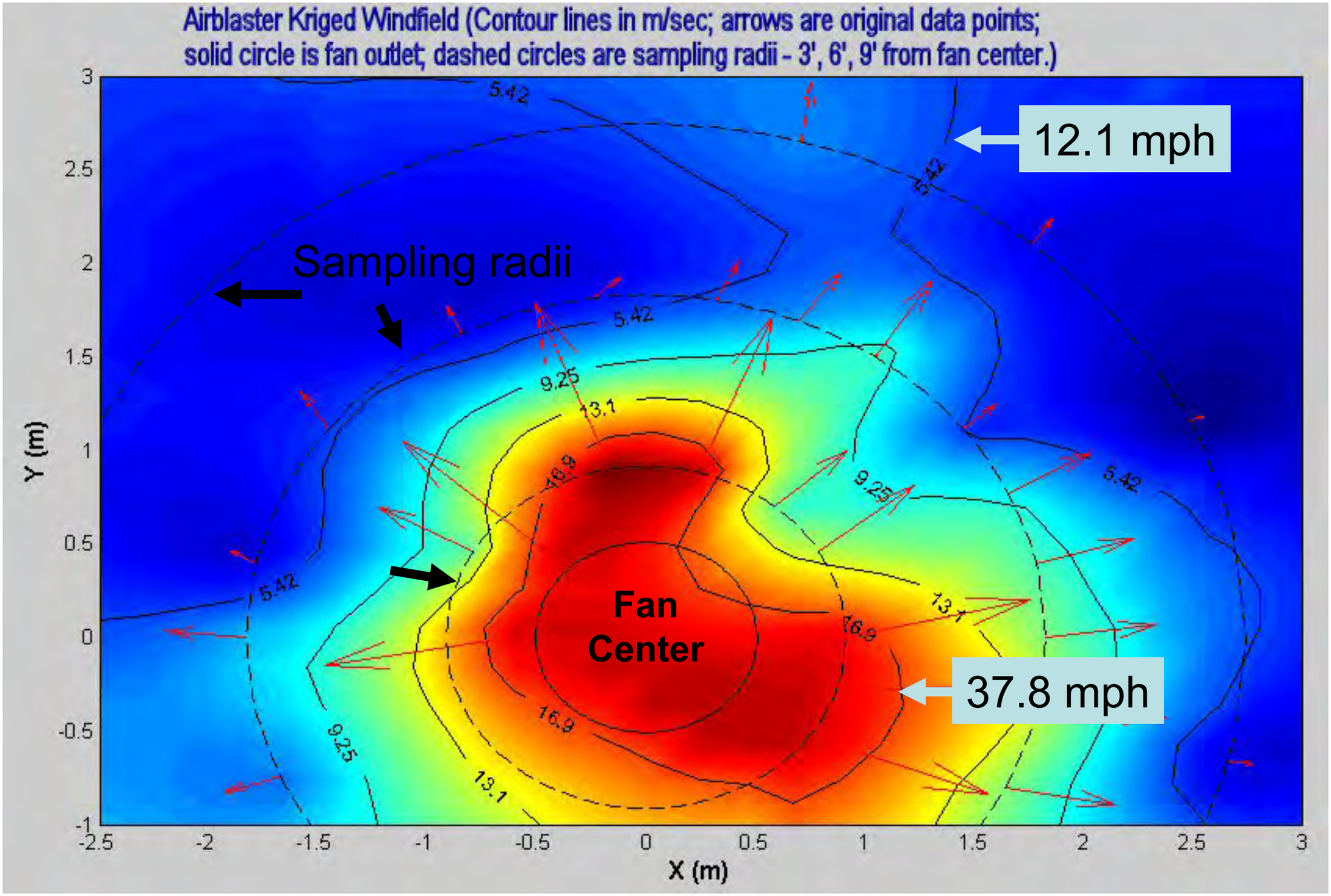
Airblast Sprayers Used in Vineyards

Note how the fan cowling is divided into two independent sectors on this axial fan airblast sprayer

Sonic Anemometer Measurements of Windfield Around a Pak-Blast Sprayer



Kriged Windield Around an Axial Fan Air Blast Sprayer (contour lines = meters/sec)



How Far is the "Boom" on an Air Blast Sprayer from the Target?

Turbomist Tower Sprayer

Proptec Spray Head Nozzle & Fan

Blueline 6 Head Telescoping Vertical Boom Proptec Sprayer

Atomized Spray from Proptec Head

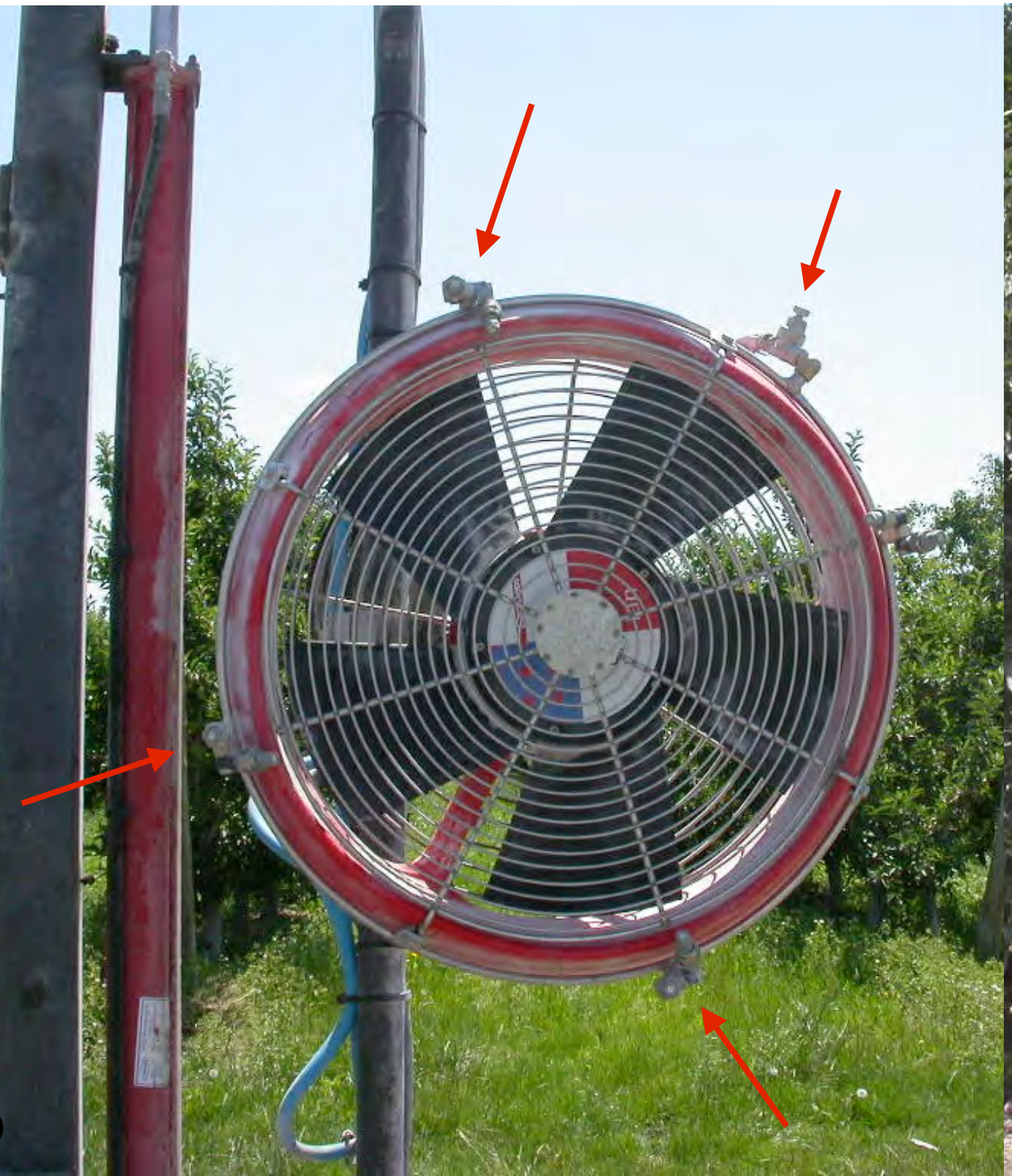
Proptec Mounted on a T-Boom

Blueline 8 Head Wrap-Around Proptec Sprayer

Proptec Sprayers for Orchard Use (The Tower)

The Quantum Mist Sprayer (note that pressurized nozzles surround the fan cowling)

The Quantum Mist Sprayer
(note that pressurized nozzles surround the fan cowling)



How Not to Operate a Proptec Sprayer

Horizontal Boom on Proptec Orchard Sprayer

Advantages of Tower Sprayers

- One consideration when preparing a spray tank mix is the volume rate of spray

  ✓ For example, typical orchard sprays are applied at the rate of 150 - 200 gallons per acre

- Tower sprayers are typically reduced volume sprayers

  ✓ Volume rates as low as 20 gallons per acre are possible

  ✓ Tower sprayers also move faster than air-blast sprayers (~4 mph vs. 1-2 mph)

- Thus, tower sprayers can save time from repeated tank fill ups as well as cut labor costs and worker exposure to hazardous materials

- Tower sprayers also place the spray closer to the foliage than do airblast sprayers, reducing wastage

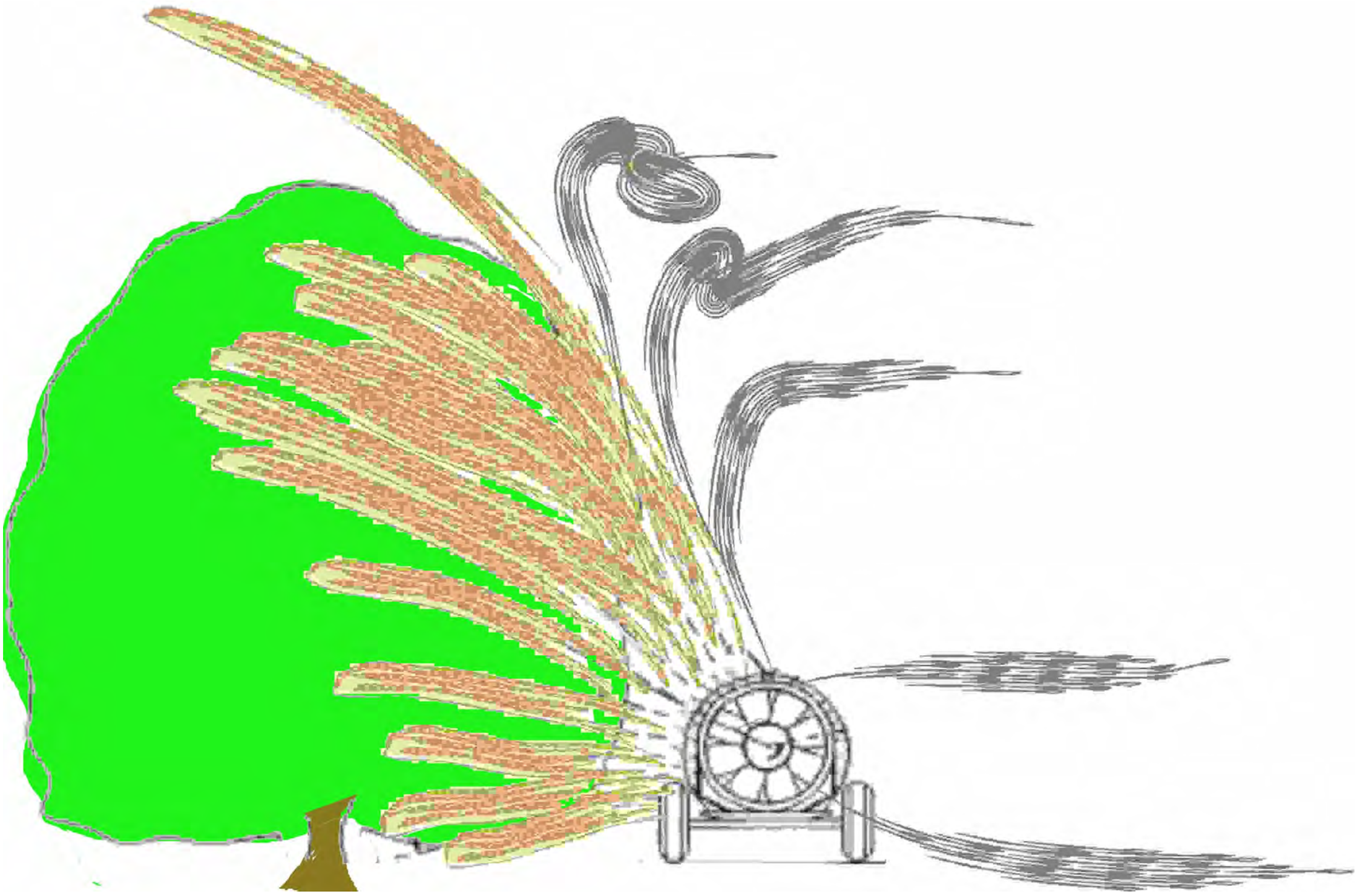
Spraying Outside Rows with One Set of Nozzles Open

The Backwash Effect

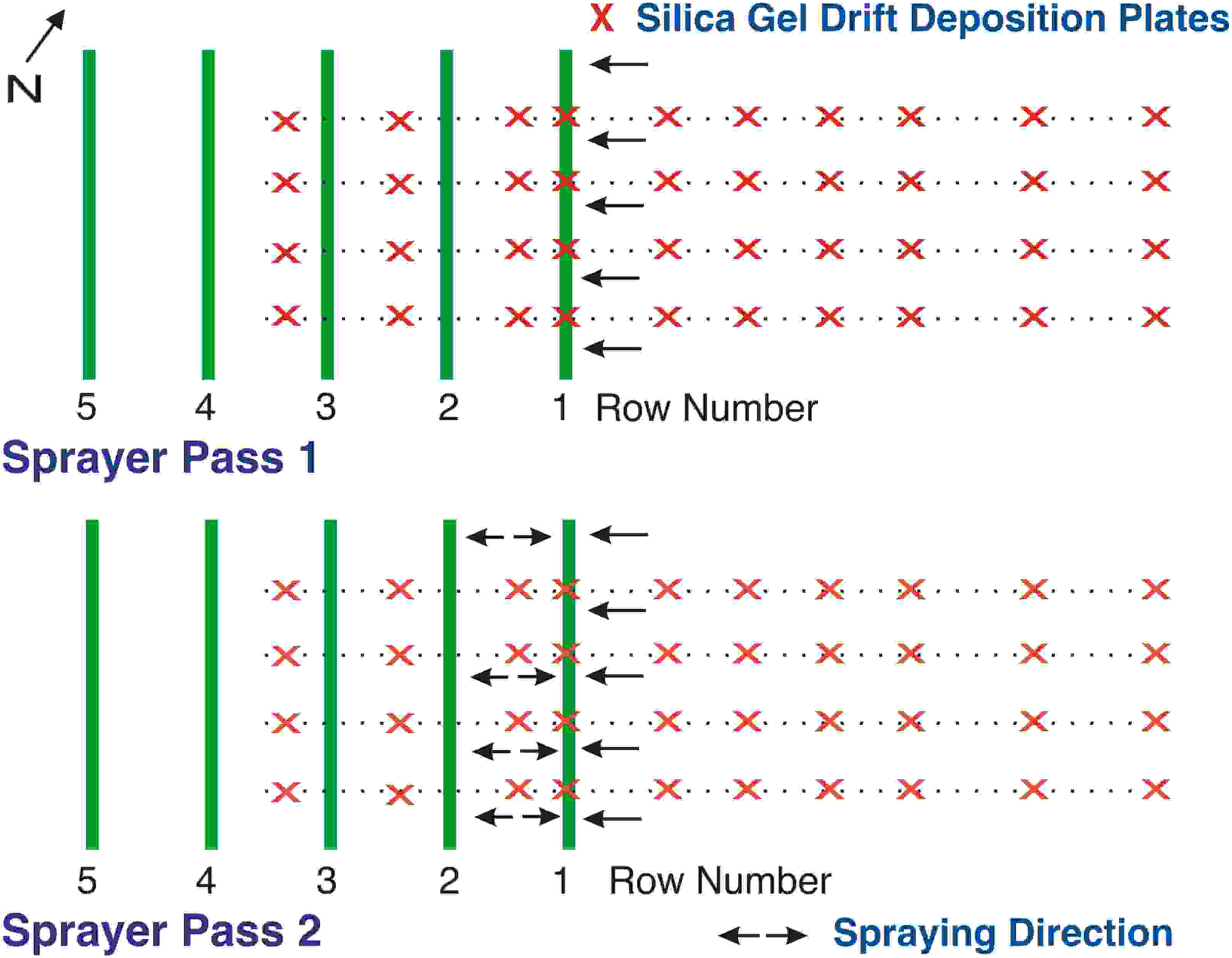
The Backwash Effect


KUBOTA

How Much Does the Air Backwash Effect Contribute to Out of Orchard Drift??



FEQL 2005 Spray Drift Study: Documenting the Air Backwash Effect



Outside Row Sprayed

Outside + Row 1 & 2

Ground deposits of Guthion due to drift

Guthion µg/cm²

1

0.1

0.01

0.001

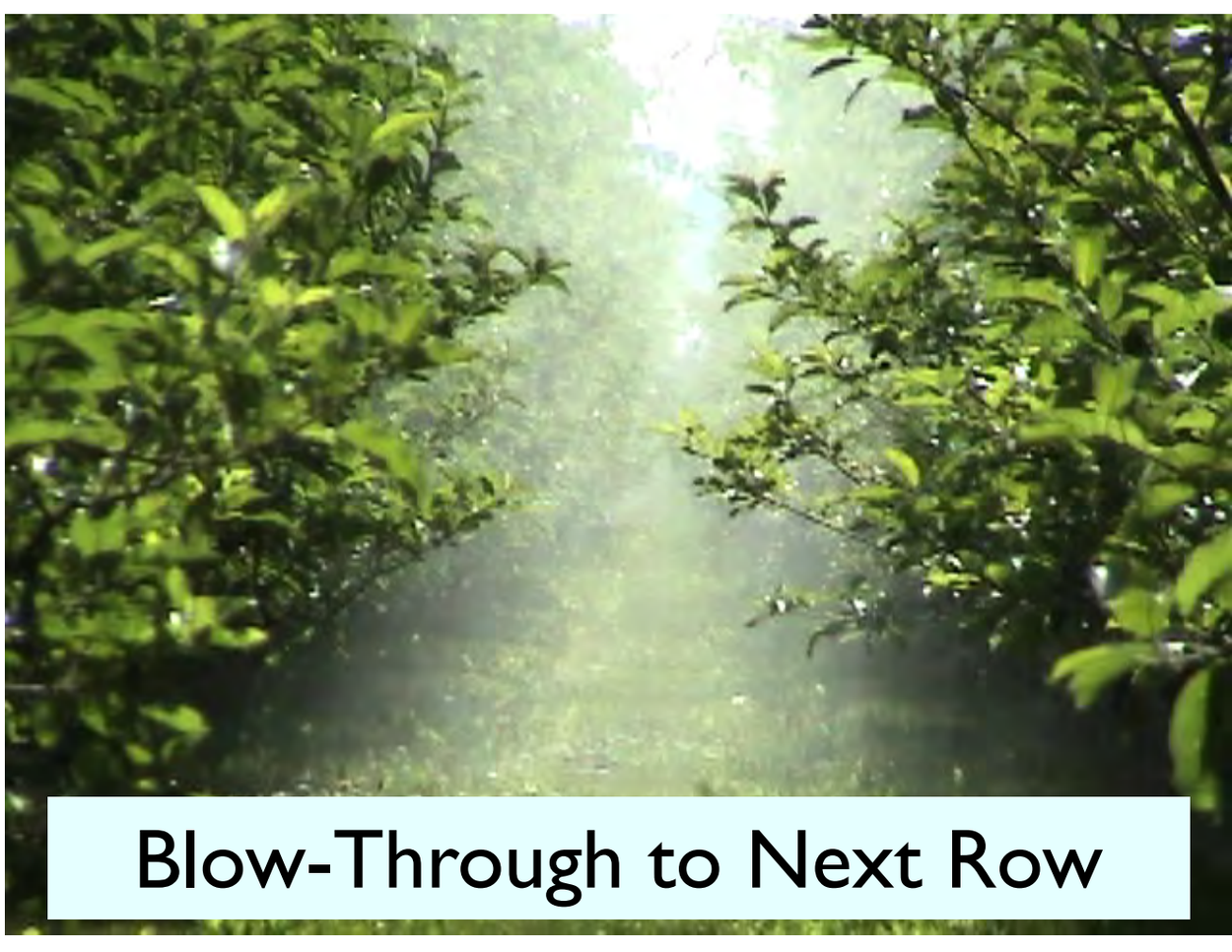
Inside Orchard

Outside Orchard

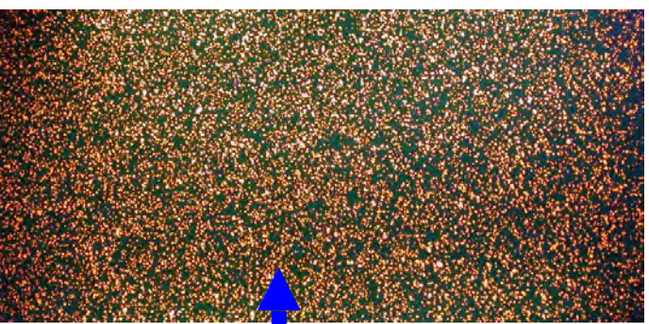
-40 -20 0 20 40 60 80 100

Distance (feet) from First Tree Row

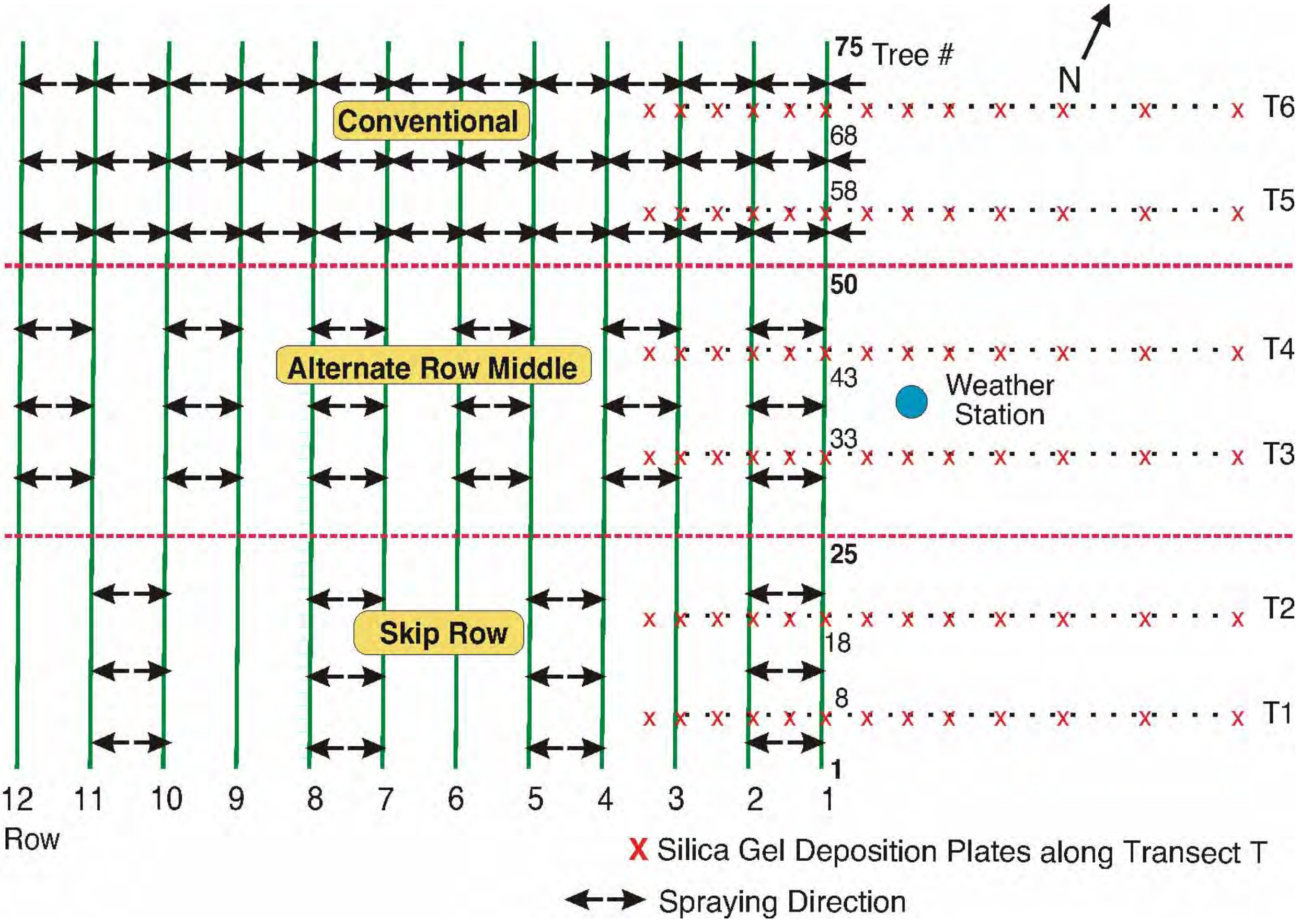
Manifold Shields: An Easy Solution to An Avoidable Problem??



Within Canopy Movement & Deposition of Orchard Sprays



Fluorescent Tracer Deposition

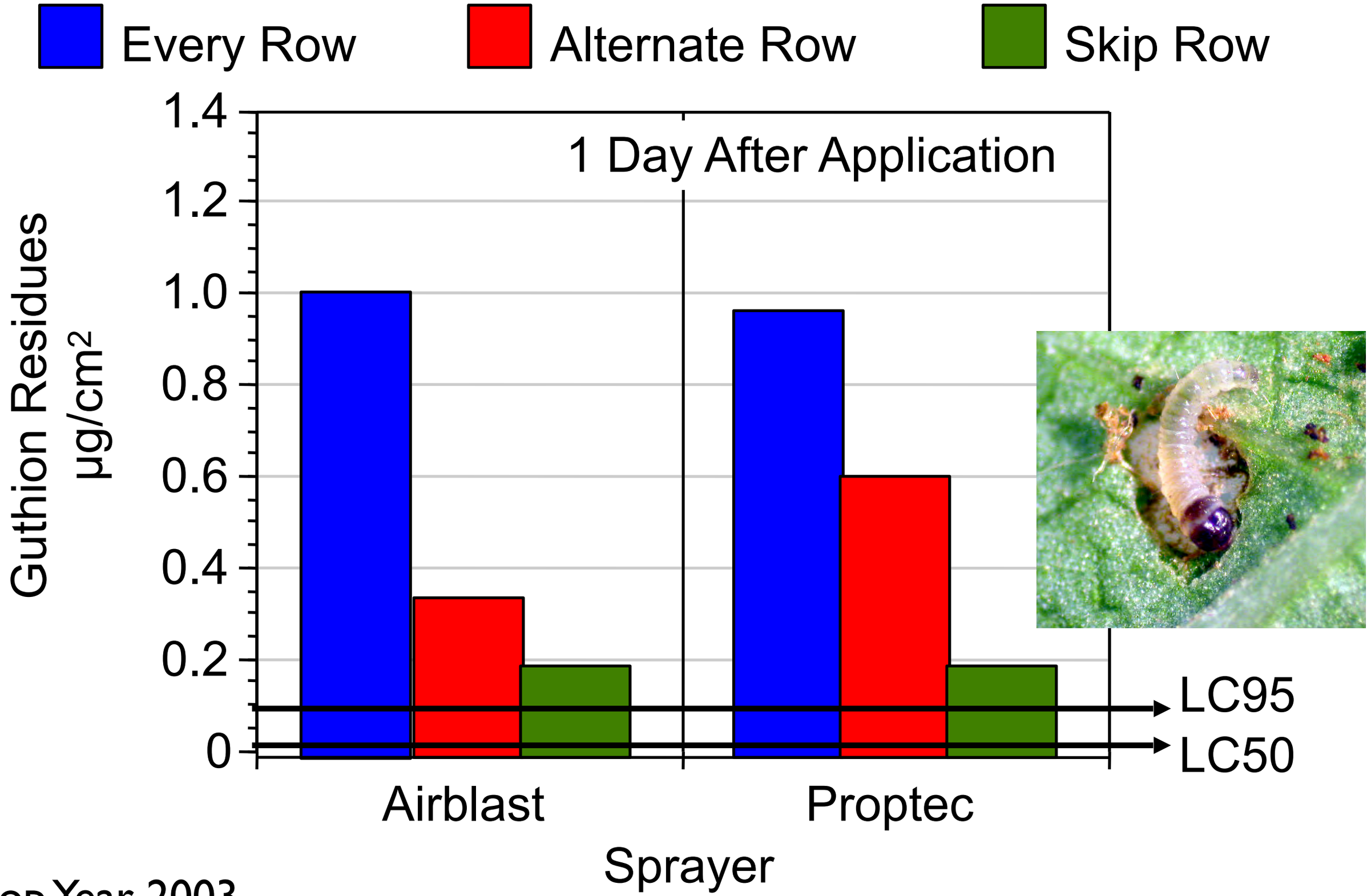

75
Tree #
N
Conventional
T6
68
58
T5
50
Alternate Row Middle
T4
43
Weather Station
33
T3
25
Skip Row
T2
18
8
T1
1
12 11 10 9 8 7 6 5 4 3 2 1
Row
X Silica Gel Deposition Plates along Transect T
Spraying Direction

Every Row (Conventional)

Alternate Row Middle (ARM)

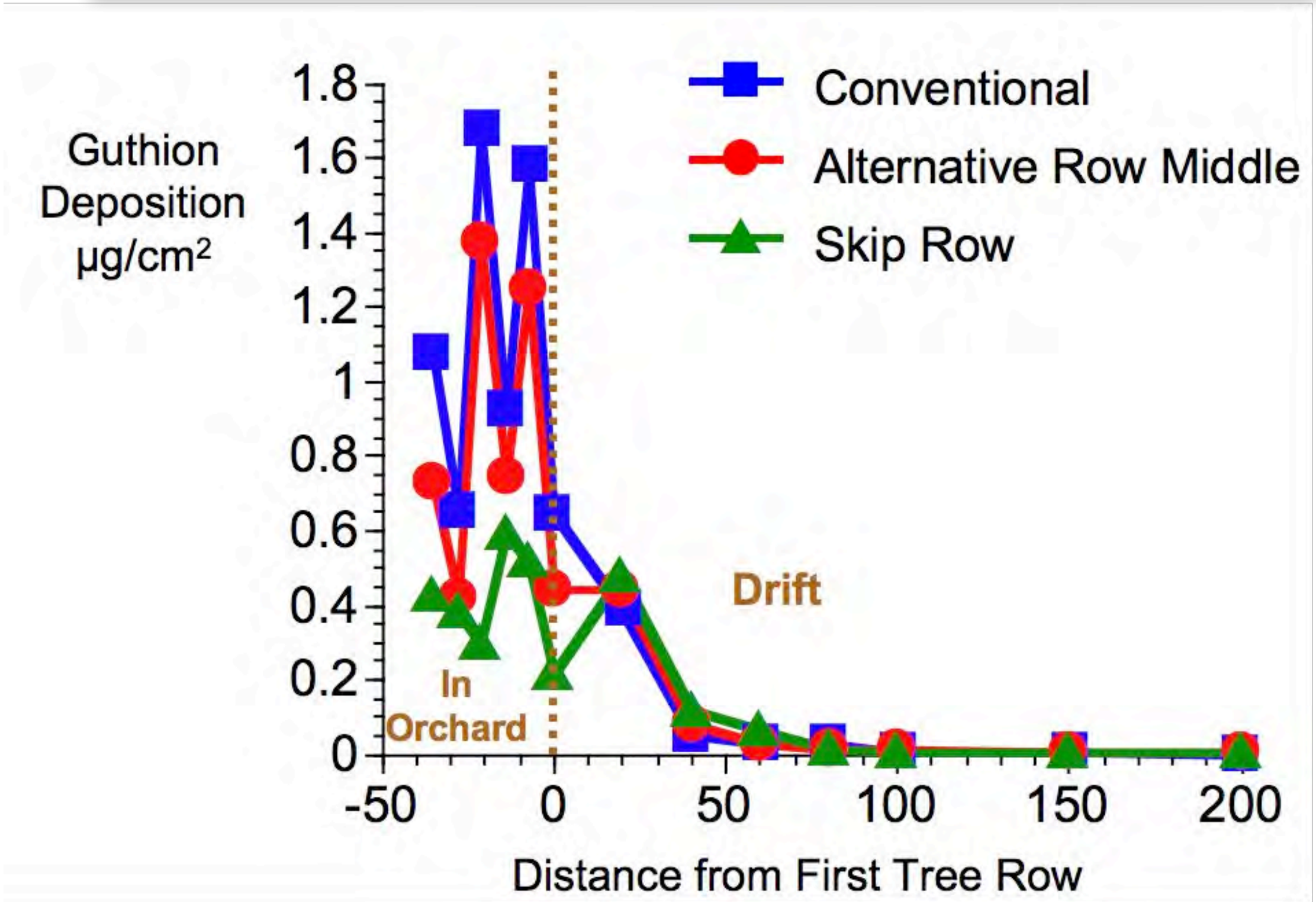
Skip Row (SR)

Guthion (azinphos-methyl) Residues on Field Treated Foliage

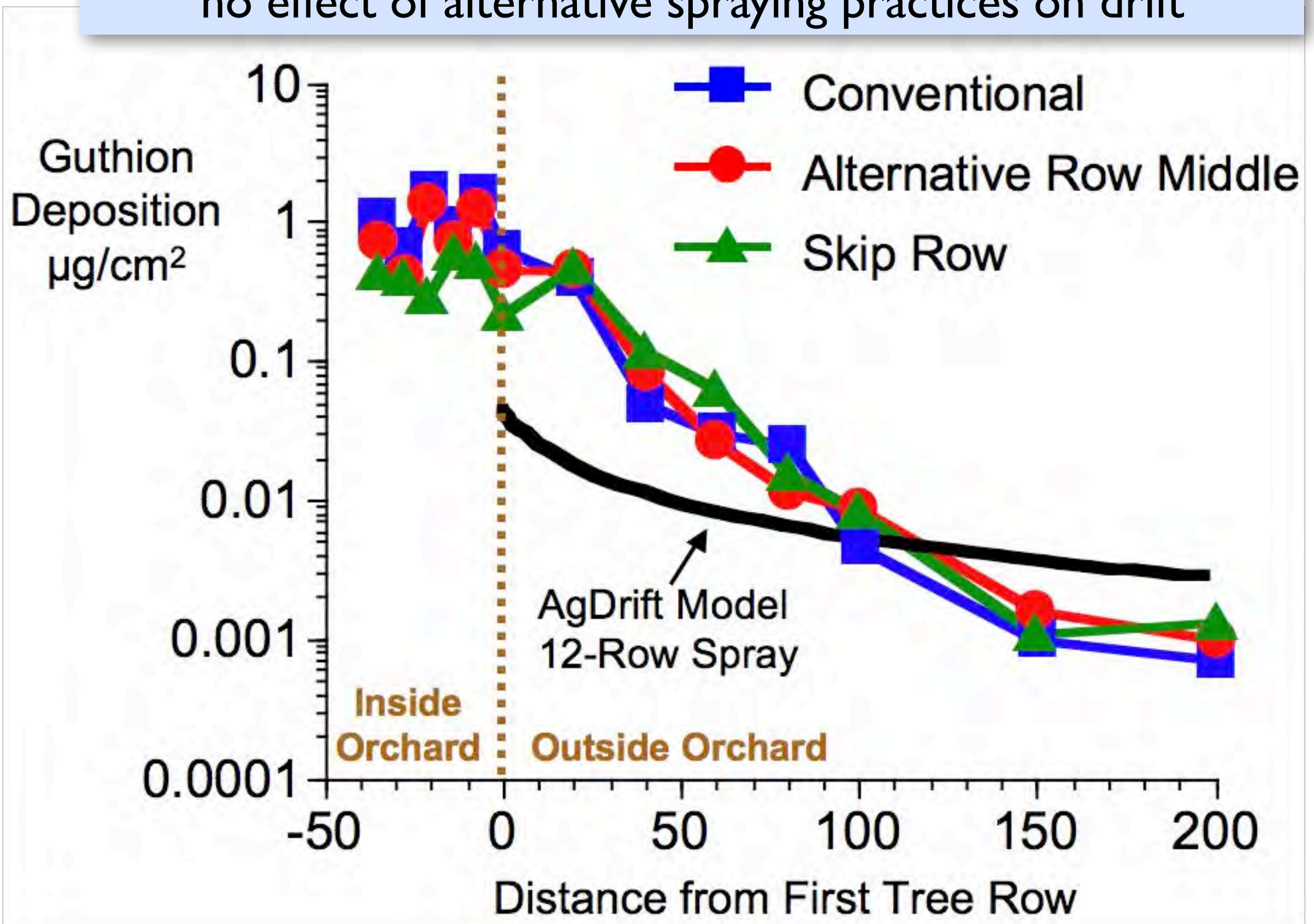


Crop Year 2003

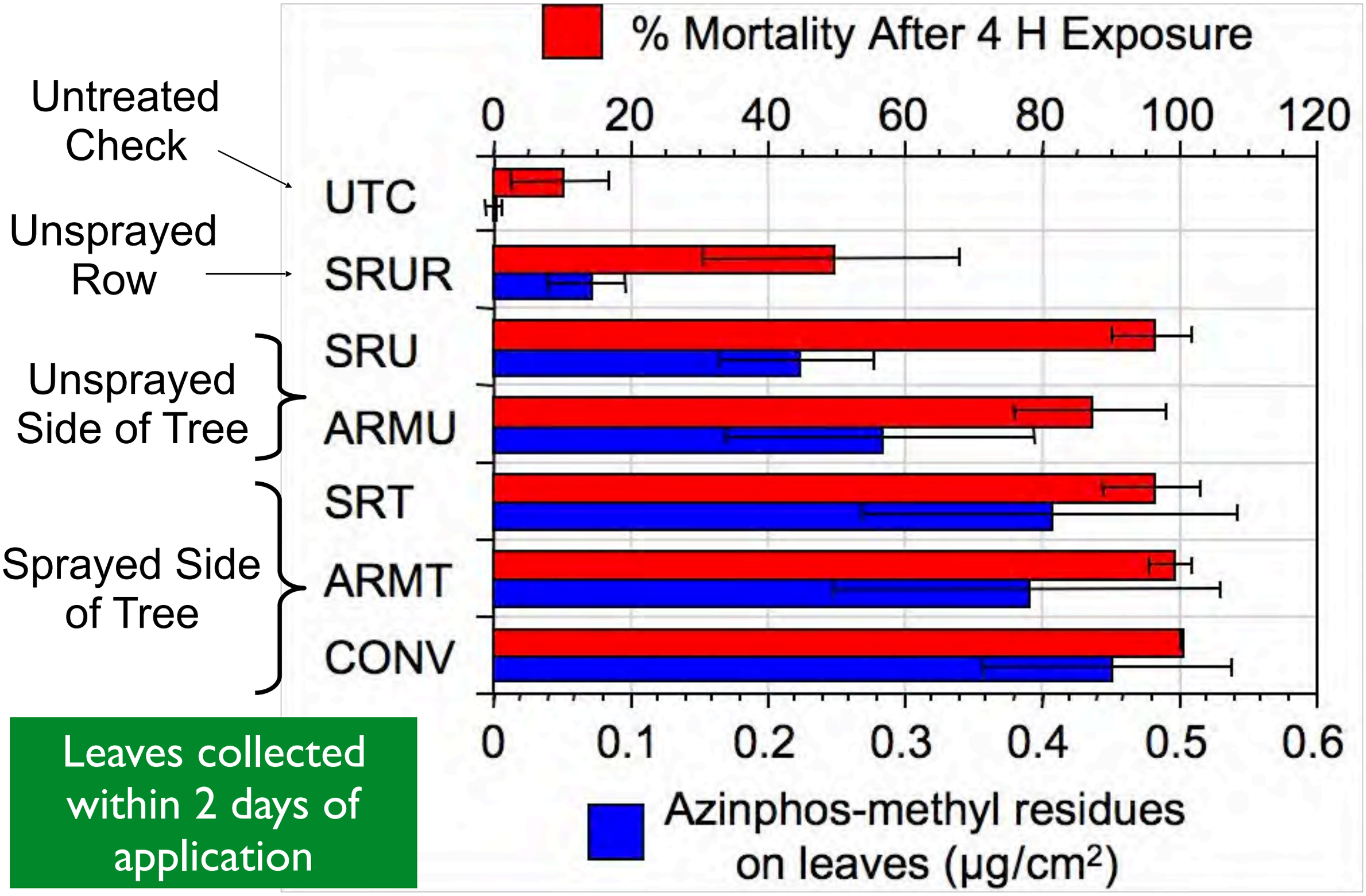
Conclusion: Significantly less ground deposition in orchard when a row is skipped



Conclusion: Under the conditions of the experiment, no effect of alternative spraying practices on drift

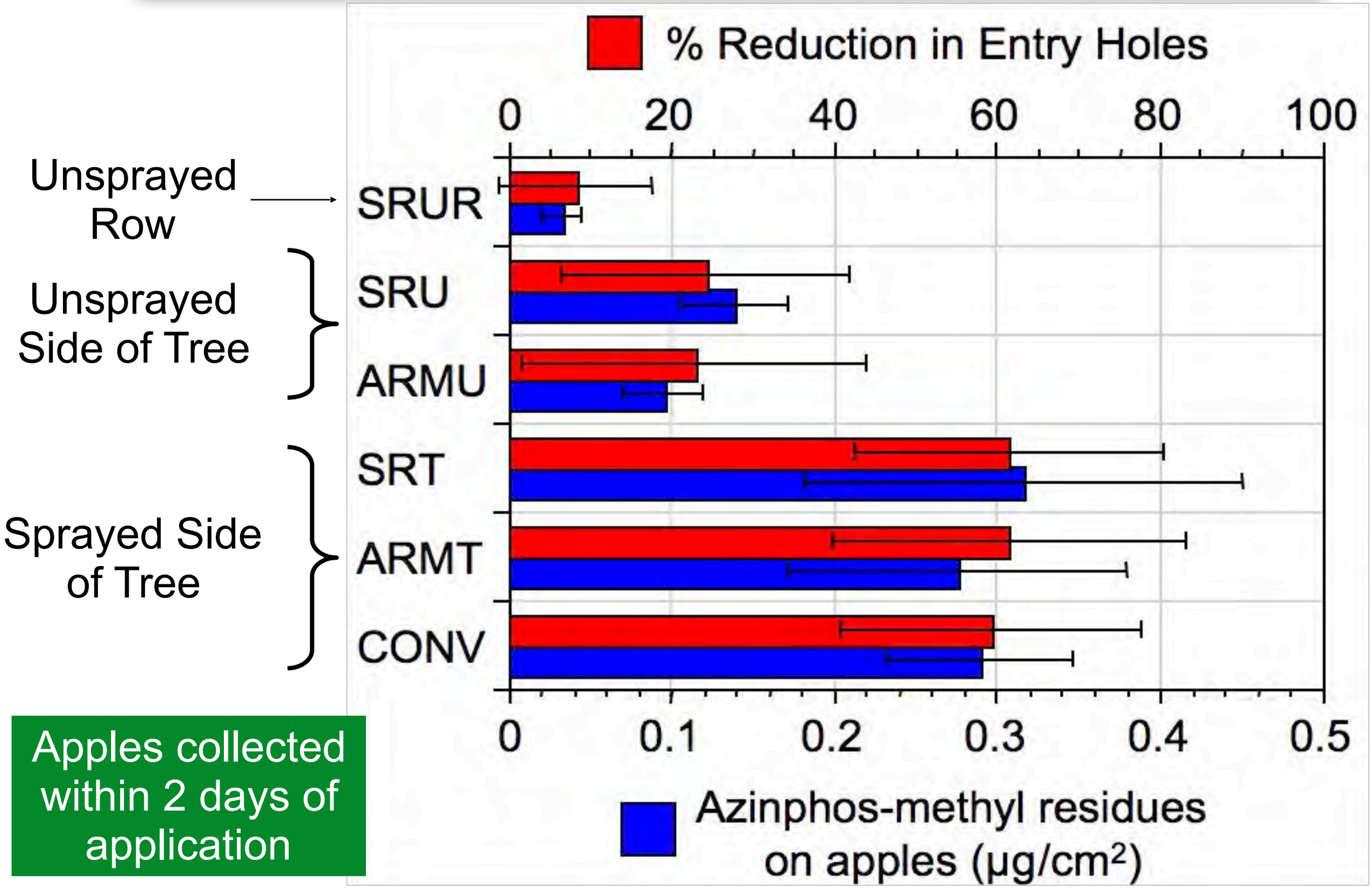


Conclusion: Leaves from the untreated side of the tree have less residues but mortality of codling moth neonates is about the same as on leaves from the treated side of the tree



Leaves collected within 2 days of application

Conclusion: Residues on apples are less effective than on leaves in controlling CM larvae; residues on apples from untreated side of the tree are insufficient for adequate control of larval penetration



Apples collected within 2 days of application

Hand & Backpack Sprayers

Greenhouse Spraying: Backpack Sprayers & Foggers

Greenhouse Spraying: Robotic Boom & Stationary Thermal Pulse Foggers

NORTHWEST BERRY & GRAPE INFORMATION NETWORK

USDA-ARS
OREGON STATE UNIVERSITY
UNIVERSITY OF IDAHO
WASHINGTON STATE UNIVERSITY

Web Site Feedback

Tools
- Pest Alert
- Ask an Expert
- Discussion Groups
- Calculators
  - Boom Sprayer Calibrator
  - Airblast Sprayer Calibrator
  - Cost of Grape Production Calculator
  - Organic Fertilizer Calculator

Upcoming Events

10 June:

OSU Strawberry Open (2:00 pm)

Airblast Sprayer Calibrator

Sprayer calibration should be done at least once per season, but preferably every time there is a significant difference in the desired spray volume (gal/acre). For example, early-season applications cover a small canopy and therefore require a lower spray volume for thorough coverage compared to later applications to a full canopy. This worksheet is intended to take you stepwise through the calibration process.

1. Determine tractor speed.

Establish a preferred operating speed.
In a pre-set gear, note the throttle settings. Fill the spray tank half full with water for a speed test. Insert numbers into the equation below and calculate the result. For the test run:
Measure the length in feet of a row in your berry field.

Row length in ft is (A)
____

Determine the time required to travel the row at the preferred speed.

Calibrate, Download, Print

1. Determine tractor speed.
2. Check spray pressure and spray pattern.
3. Determine required total nozzle output in gal/min (gpm).
4. Check nozzle size.
5. Check spray volume.
6. Compare actual with desired spray volume.
7. Prepare the spray mixture.
8. Print this worksheet.

Efficient spraying starts with accurate calibration

http://berrygrape.org/airblast-sprayer-calibrator/

Questions??

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