Advanced application concepts: understanding and visualizing deposition

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Application Insight LLC

Objectives:

* Discuss the factors affecting three dimensional deposition and methods to modify it in fields, orchards and vineyards

* Identify qualitative and quantitative methods to measure and relate this in research and to clients

Part 1: Understanding Deposition

The Goal: apply a minimum effective dose to *all surfaces* with minimal over-application or losses to drift or the ground.

The challenge: How do we apply spray to surfaces we can't see?

First: what's a micron?

1 Micron:

1 millionth of a meter

1/25,400 of an inch.

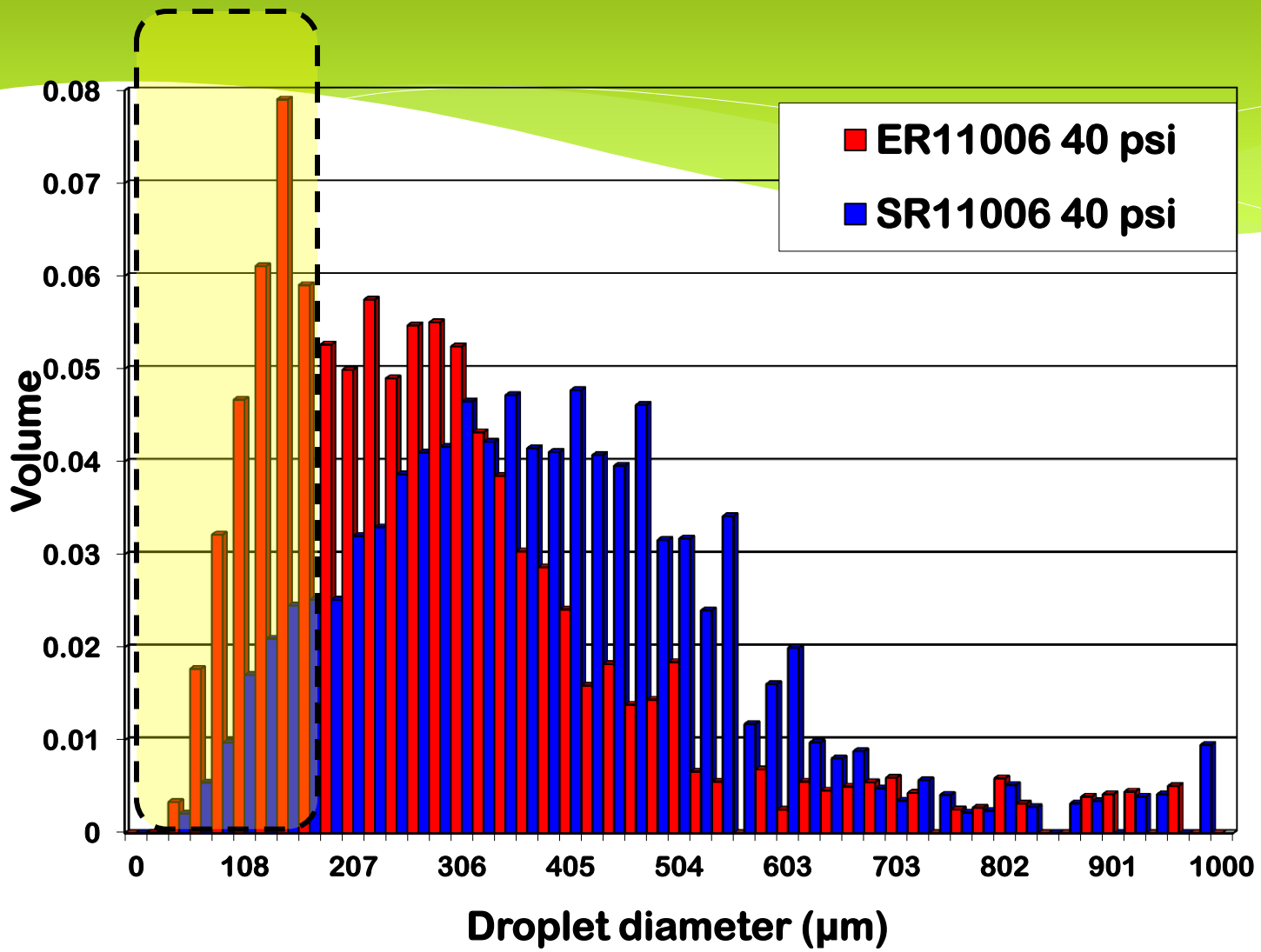
1 human hair = approximately 100 microns

Threshold of visibility for humans: about 100 micron stain

Droplet Size Comparison

Particle size (micron)	Comparative size	Time to fall 10 ft. (seconds)	Drift in 3 mph wind (feet)	Droplets/in² At 1 gpa (6 million square inches per acre)
2	Dry	25,400	112,000	144,060,000
5	Fog	4,070	18,000	9,220,000
10	Wet	1,020	4,500	1,152,500
40	Fog	64	280	18,000
50	Misty	40	175	9,220
100	Rain	11	48	1,152
200	Light	4.2	19	144
400	Rain	1.9	8	18
500	Moderate	0.9	7	9
1000	Rain	0.85	5	1

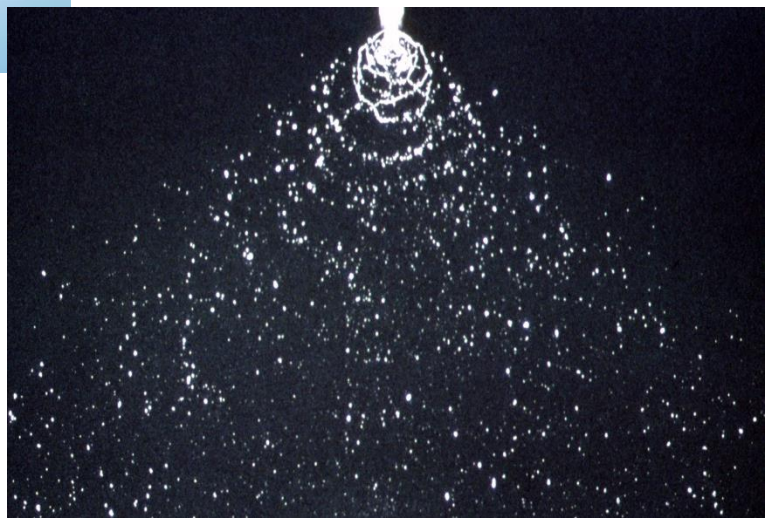
Deep-canopy targeting: the meek shall inherit the earth



Data Courtesy T. Wolf

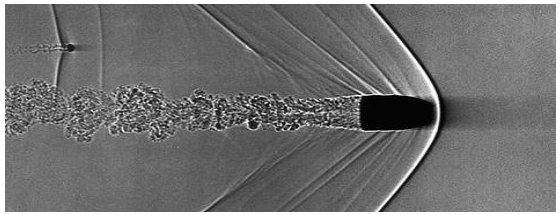
Canopy penetration: what size drops will make it INSIDE the canopy?

SPRAY SPECTRUM: MIX OF LARGE & SMALL DROPS



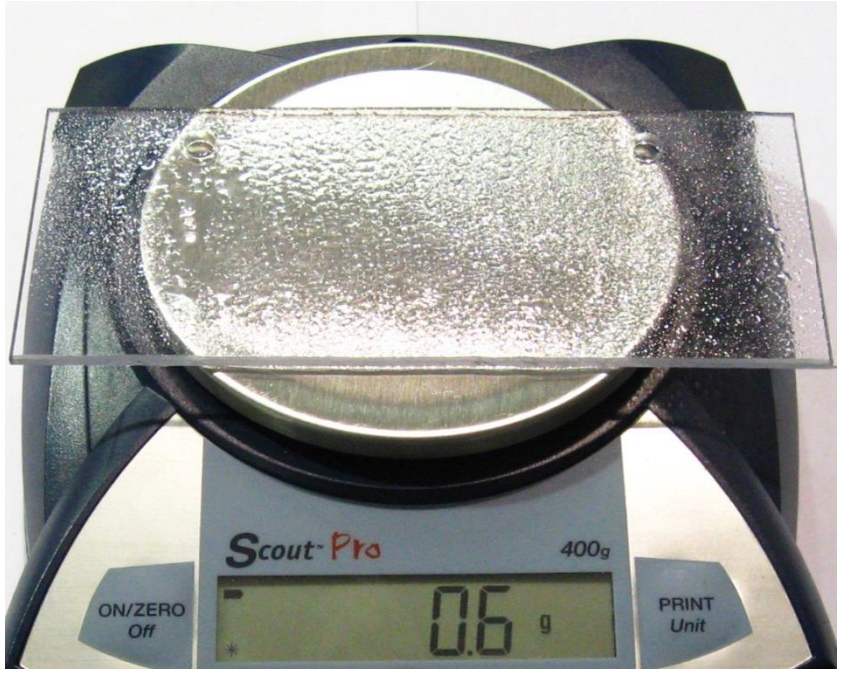
* Small droplets = feathers
* Mostly Sub 150 micron
* Can reach hidden surfaces in canopy

* Large droplets= bullets
* travel line-of sight from nozzle
* 150+ microns

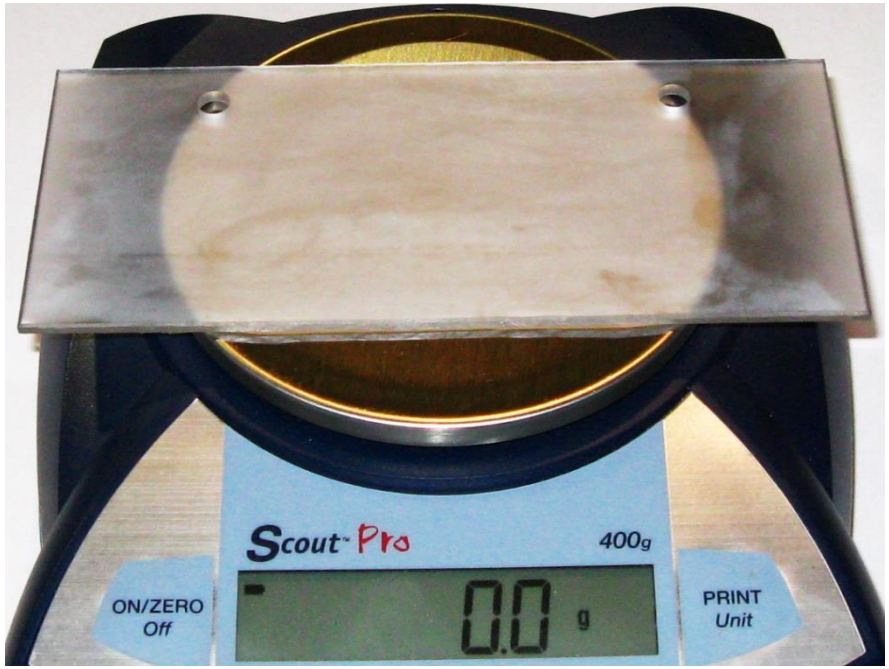


Targeting concepts: small droplets

* more uniform coverage, better MINIMUM coverage, with *much less spray solution.*



Dilute, coarse sprays: High mass transfer, inconsistent coverage



Small drop sprays: Nearly undetectable, high % coverage

Targeting concepts: why small droplets are important

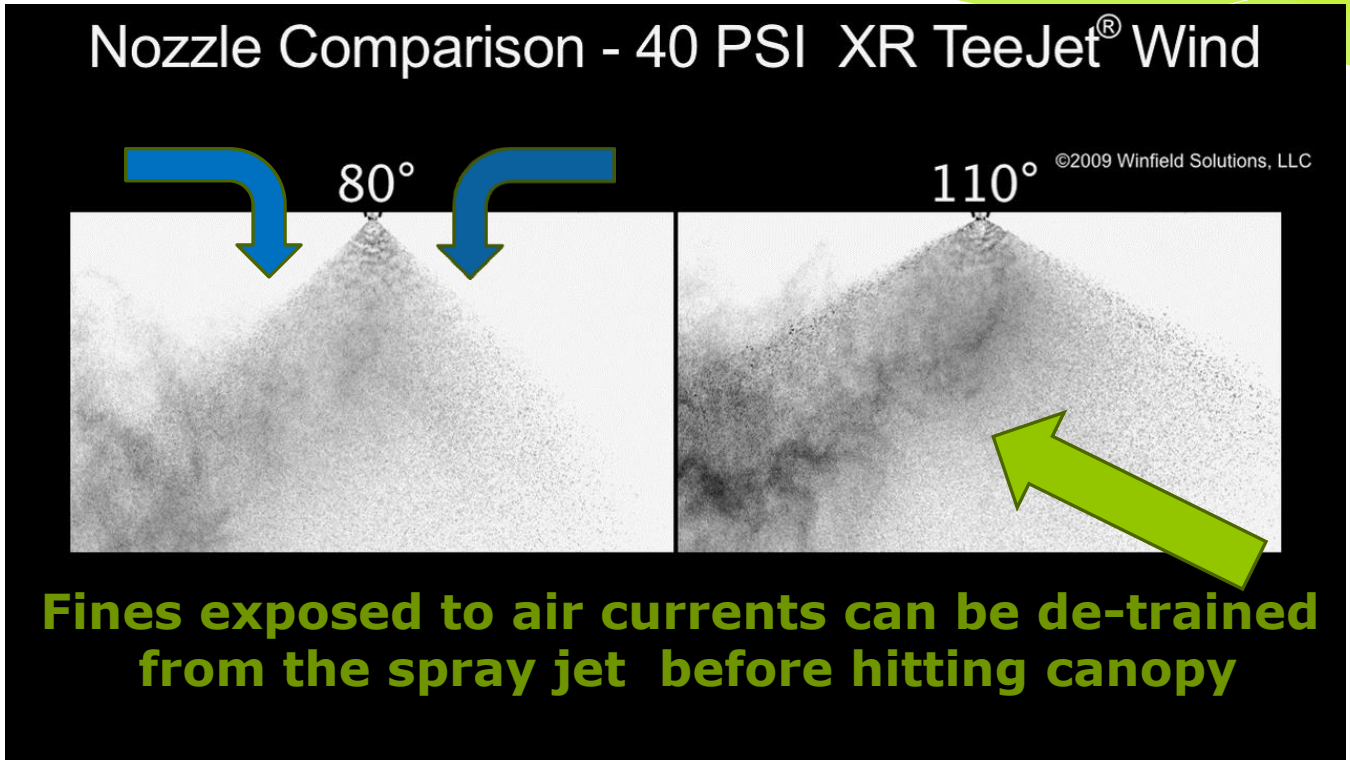
Conventional Wisdom: Small droplets don't carry enough chemical. **Reality:** It may not take much!

Two-Spotted Mite: 500 Microns. Lives on leaf bottom.

50 micron stain: a "pizza" sized meal for a mite

Too small to see unmagnified.

Release point: where droplets begin to de-train from the stream

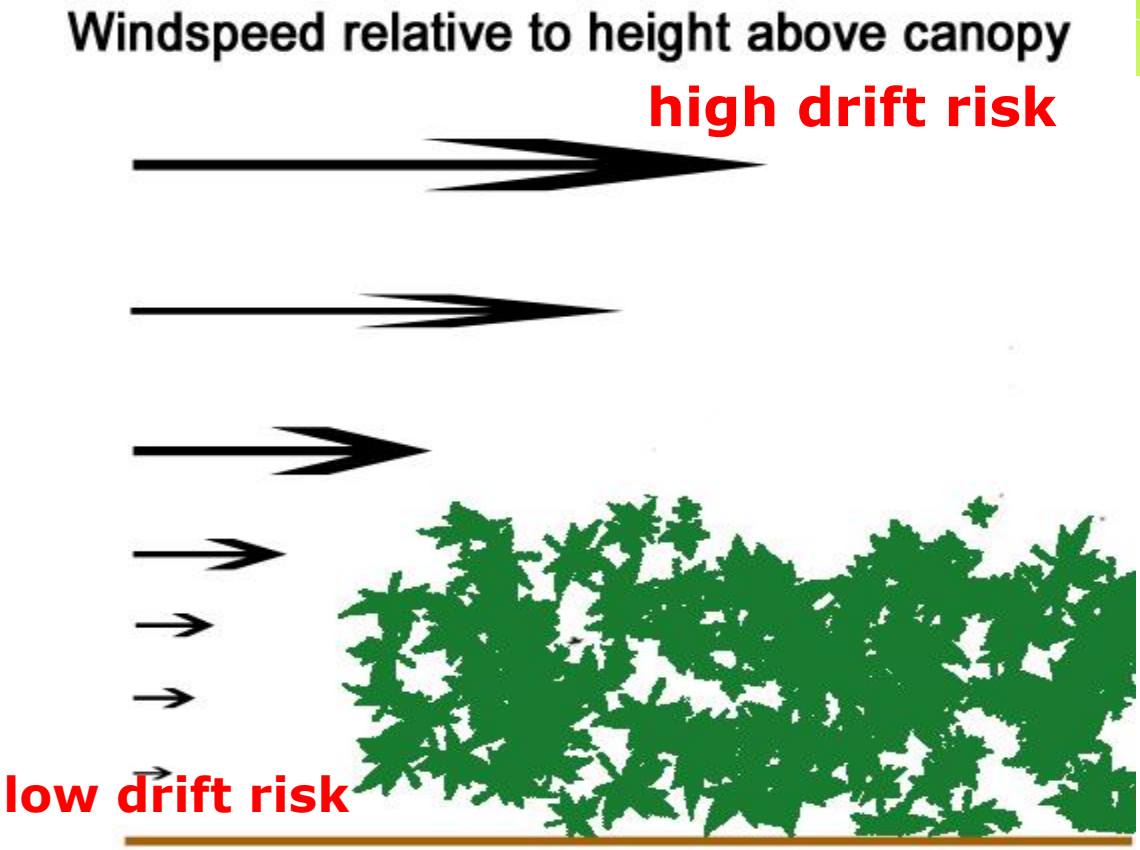


Spray jet normally entrains air (blue arrows), carrying fine droplets to the canopy with the coarser droplets

Image courtesy Winfield Solutions LLC

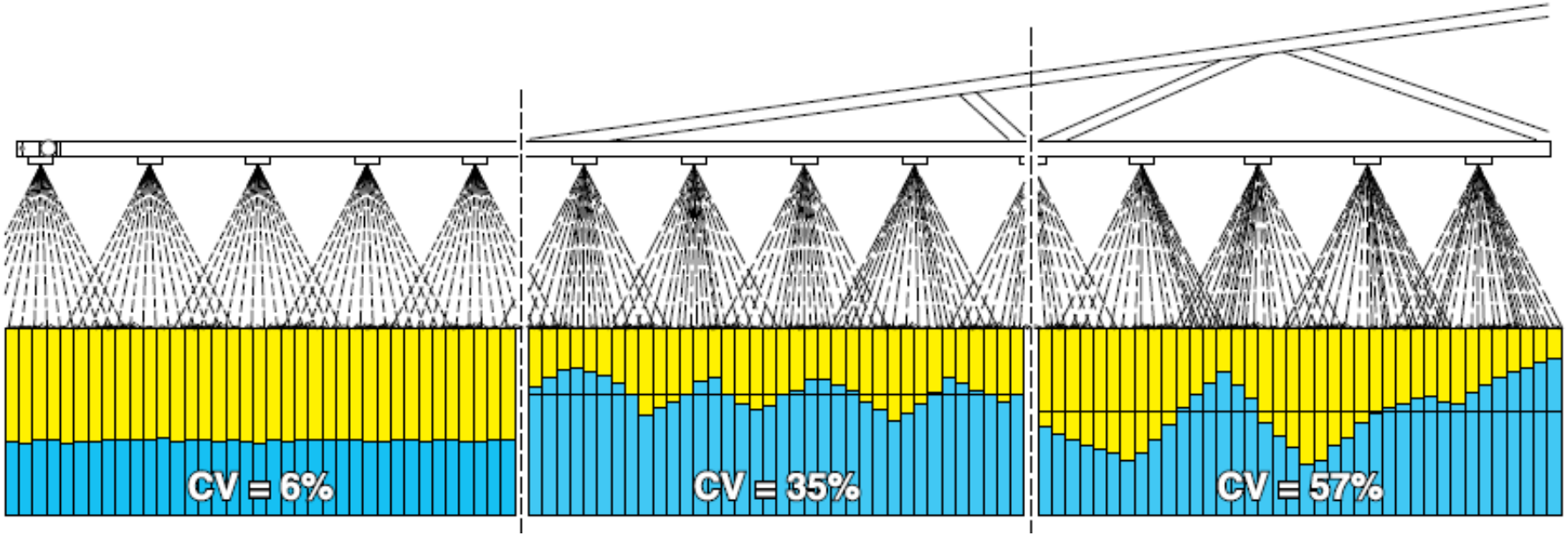
Application Speed, wind & canopy

Where your spray release point is, affects drift risk

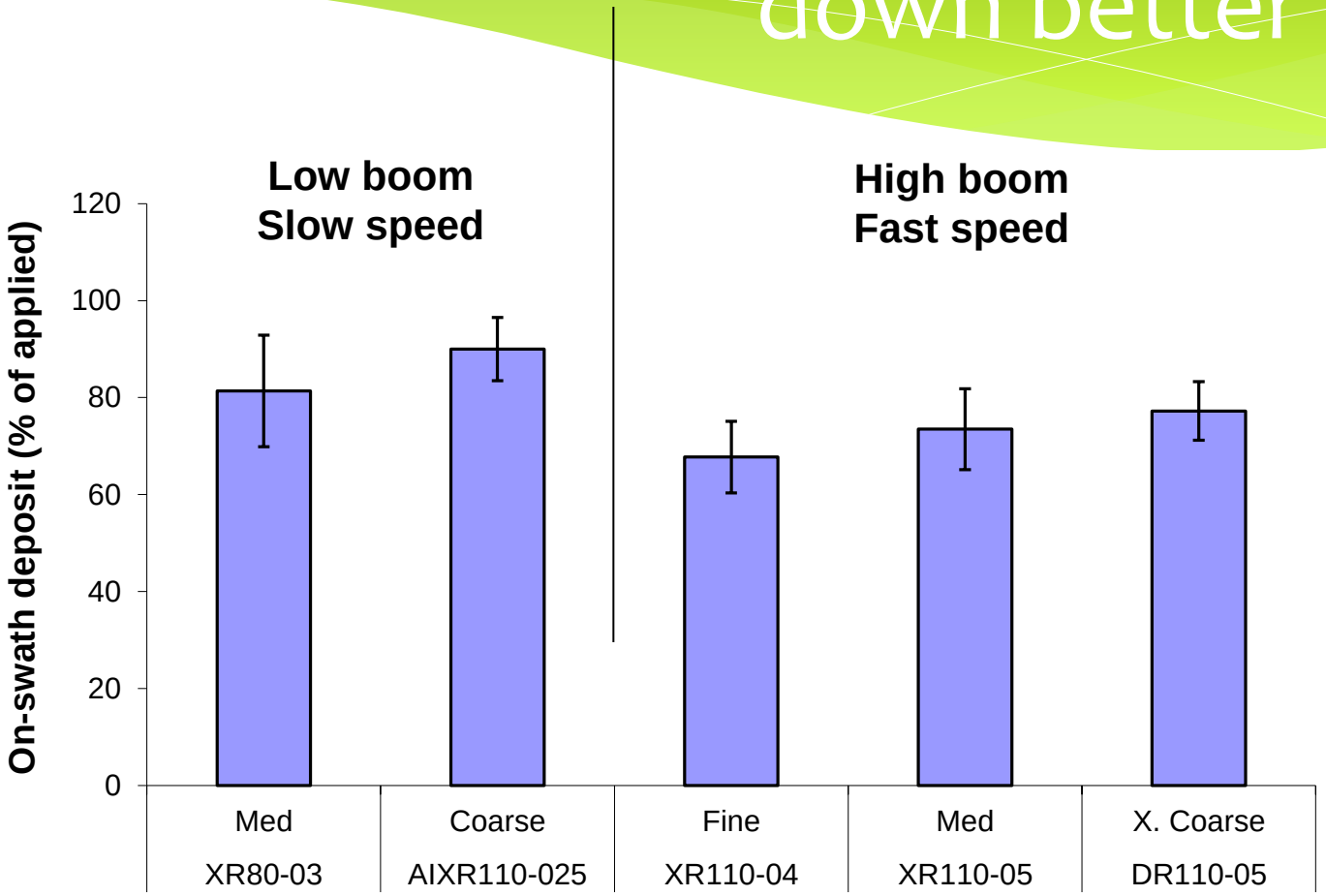


Static Pattern Measurement: Start with a good 2D distribution

2 dimensional spraying: mostly about uniform spray distribution along the boom and large droplets for direct spray transfer.

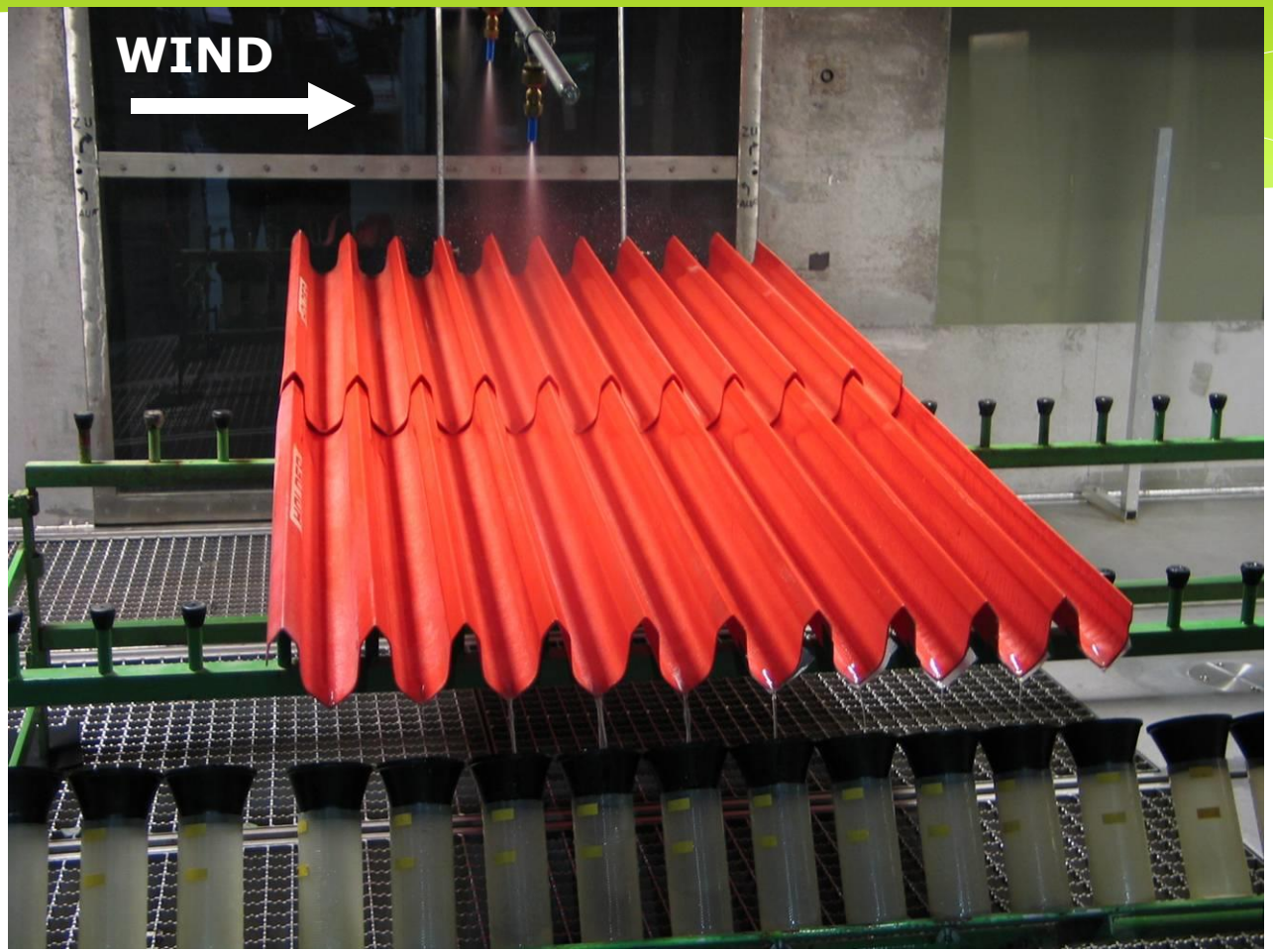


On-Swath Deposit: Slower travel, **lower release point** puts spray down better



Data courtesy T. Wolf

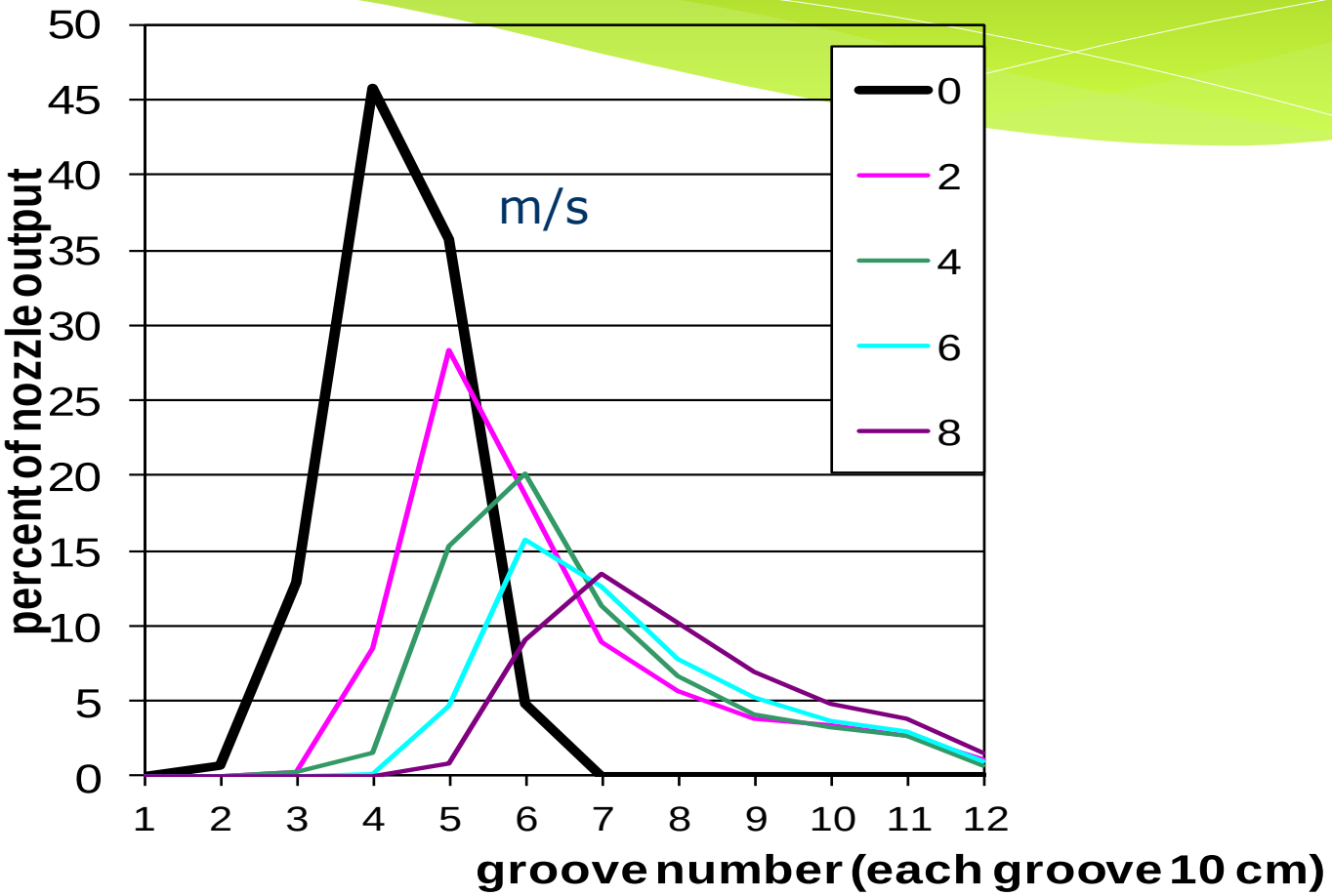
High travel speed and wind diffuse Spray stream energy



Courtesy A. Herbst, JKI, Germany

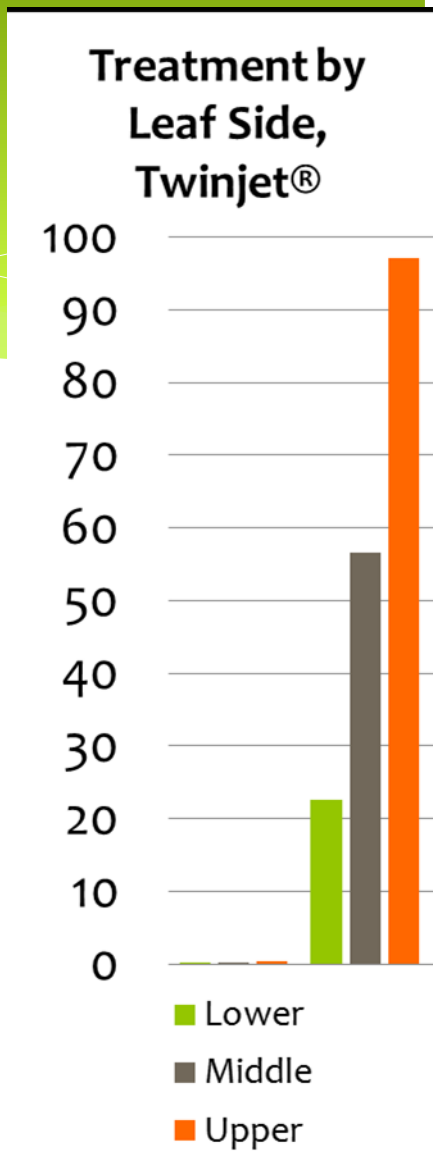
Application speed diffuses spray stream energy

XR 11003, 3 bar



Courtesy A. Herbst, JKI, Germany

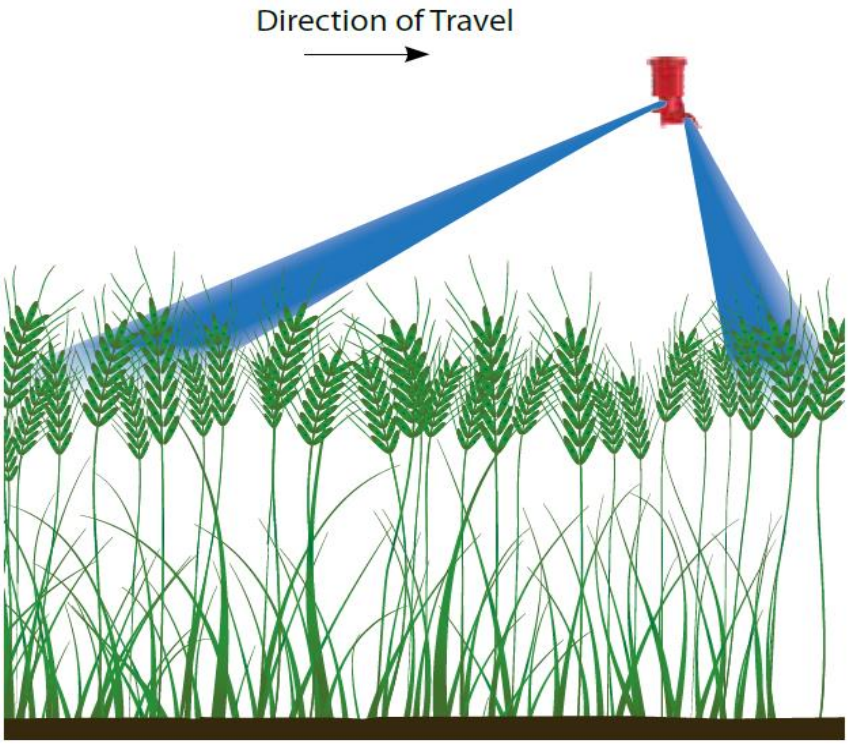
Canopy changes things!



Can be **100X difference** in coverage between top-top and bottom-bottom!

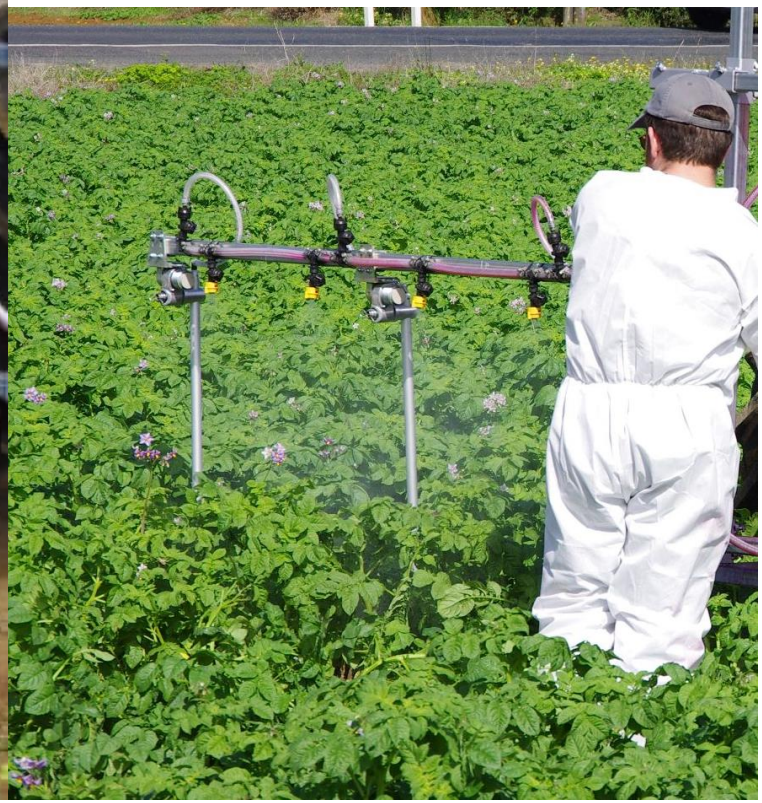
Horizontal boom 3-d deposition options: Multiple angles

More application angles can mean better in-canopy deposition, but also can adversely impact drift.

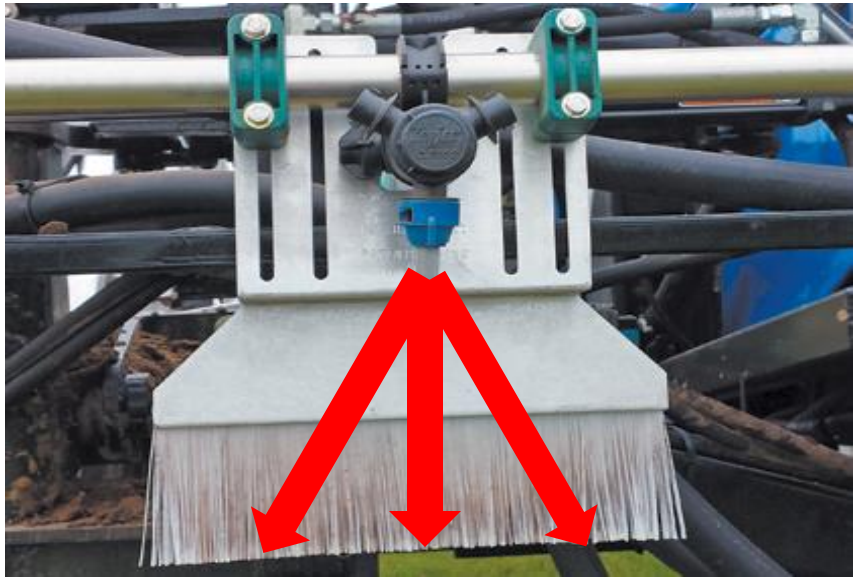


Change release point sub-canopy: drop nozzles

Micron DropSpray®



Change in release point: buff plates and spray hoods lower release point

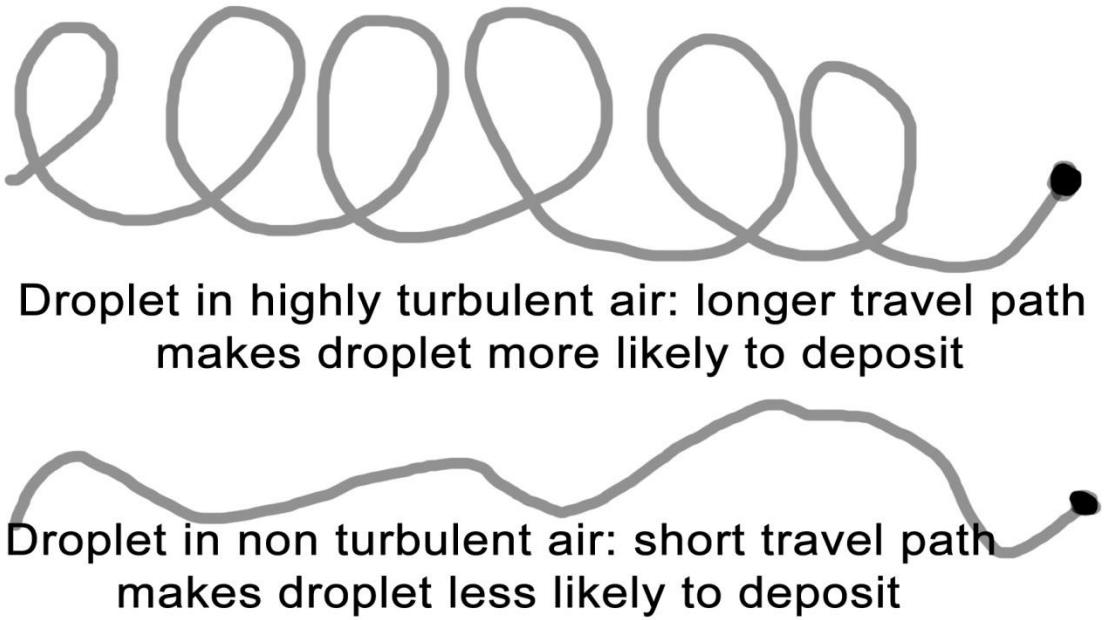


Change in release point: air assistance

* Spray laden air pushes clean air out of canopy, brings fines in.
* Most fines are **released** inside canopy where they are lower risk.
* Droppers and focused nozzle jets can significantly increase canopy penetration

Targeting concept: Turbulence and small droplets

* **Turbulence:** the ability of the air to ruffle the leaves and wrap around the backsides of solid objects. Increases overall deposition and MINIMUM coverage.

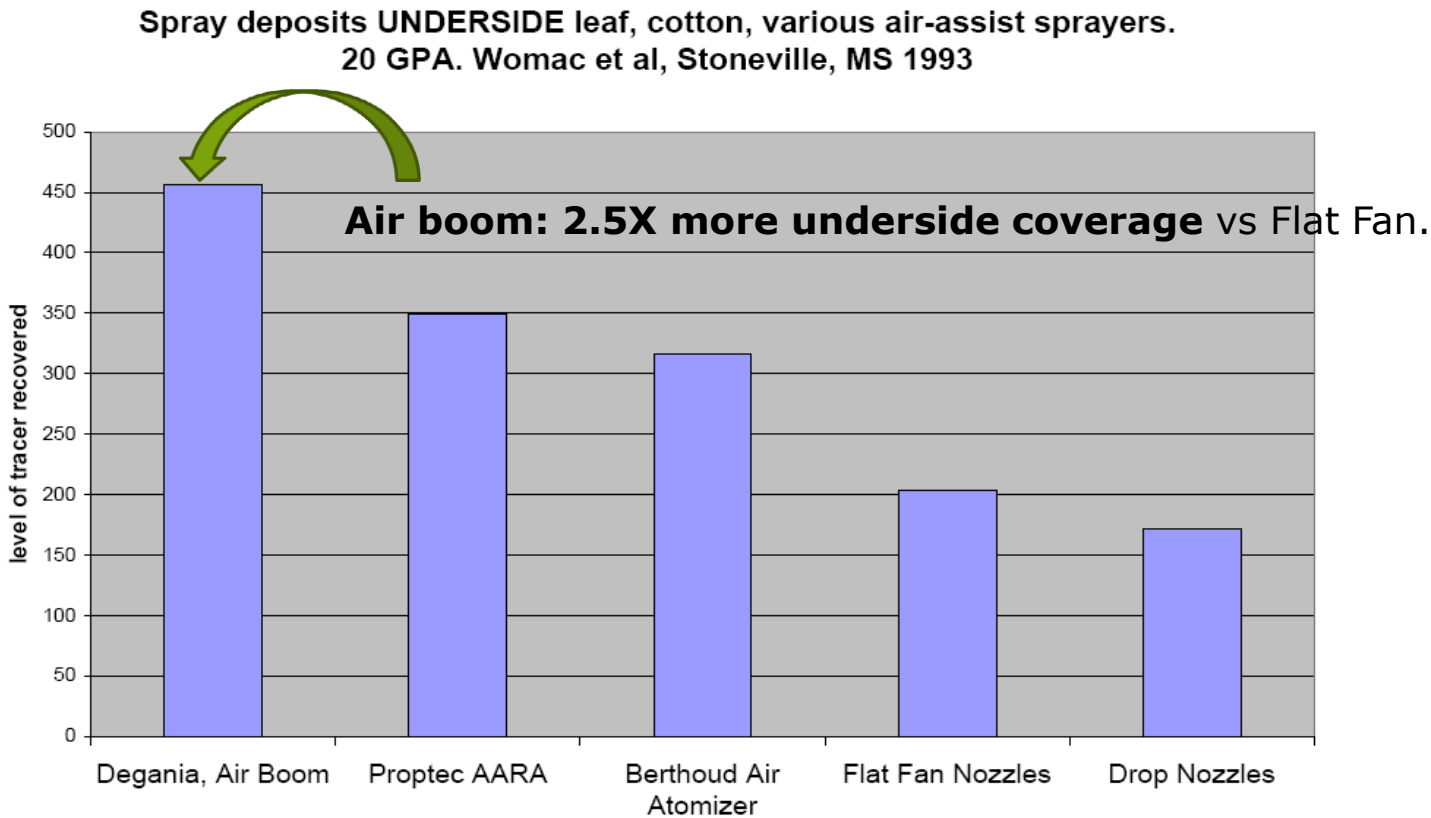


Air assistance improves most sprays where there is a canopy

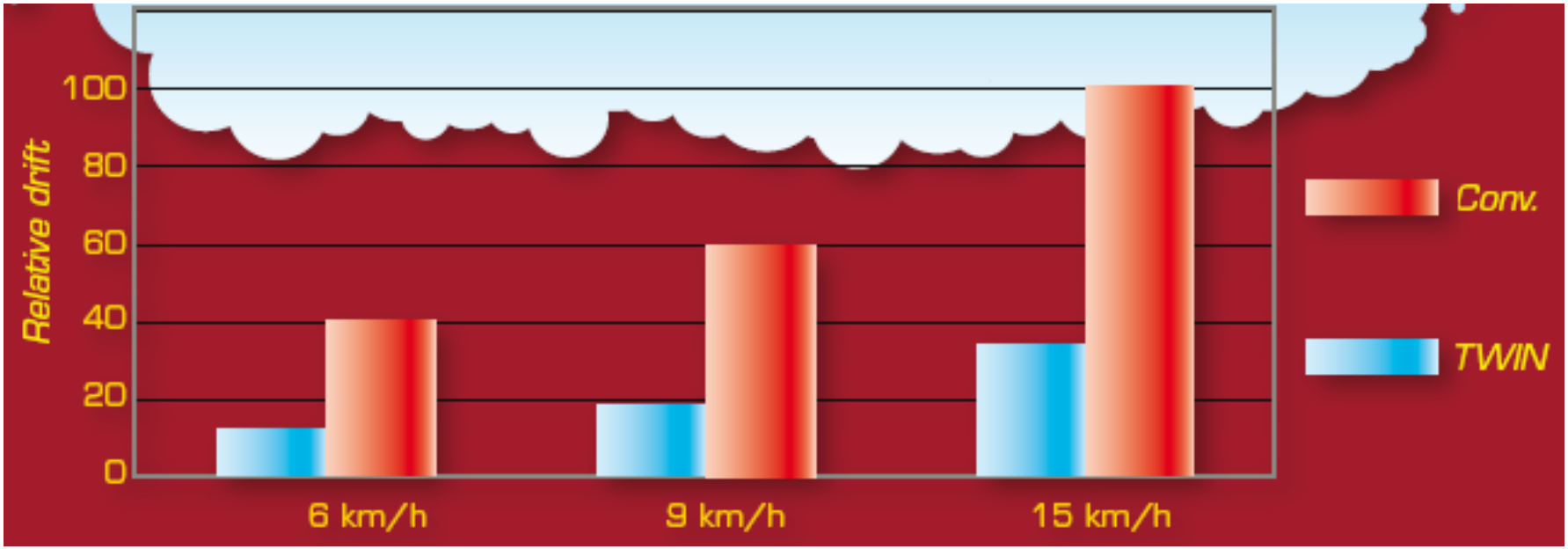
Gambetti air-boom w/ Teejet TXVK12 Full Cone Nozzles @ 400 L/ha

Air assist massively increases minimum deposits

* "The sprayers with the greatest deposit tended to be of a design that produced high velocities/volumes of air." Womac et al.

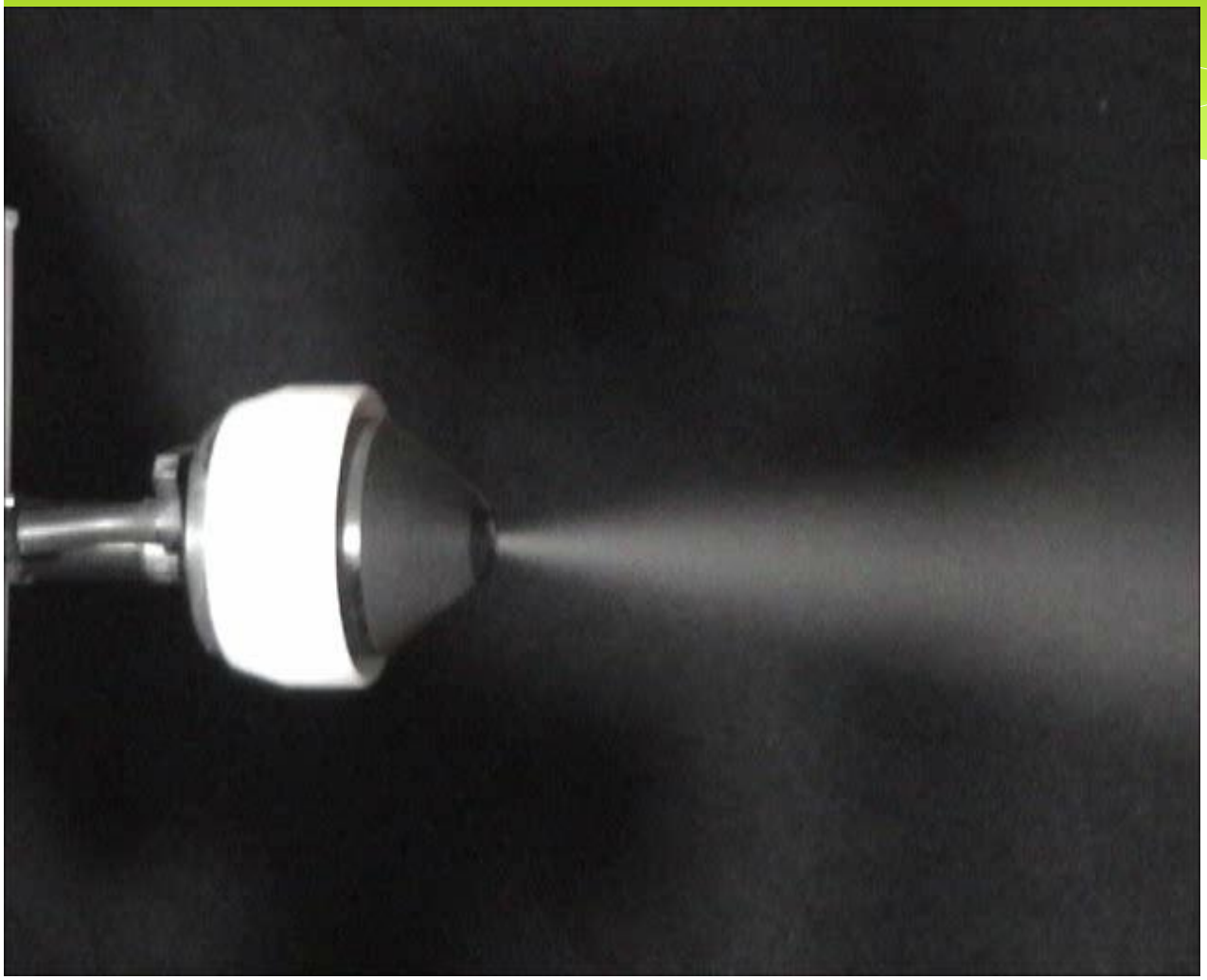


Air assistance can also reduce drift!



Data for Hardi Twin, figure courtesy Hardi Sprayers

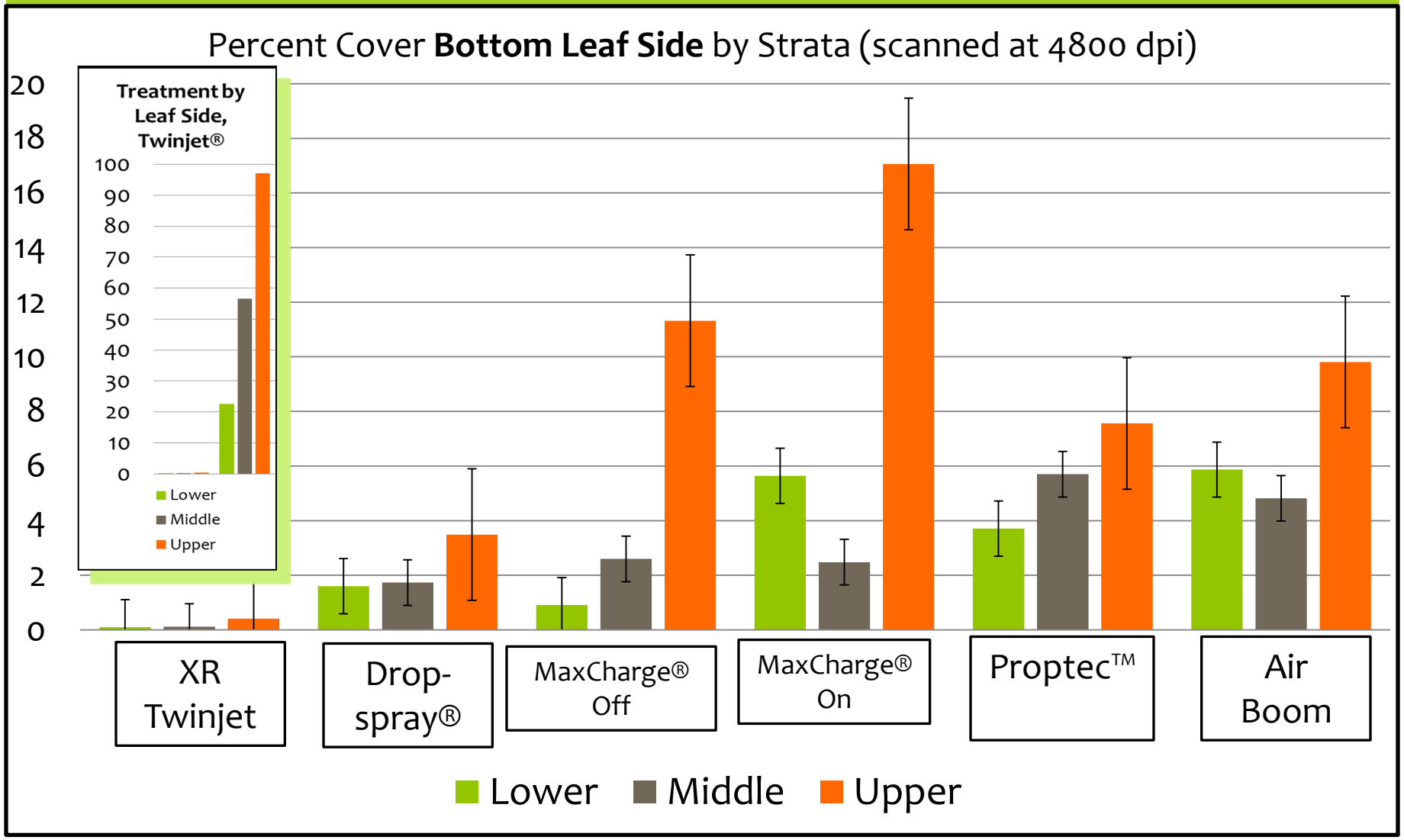
Targeting Concepts: Electrostatic effects



* Normally used w/air assist/air atomizing
* Adds induced charge to spray drops. charged droplet motivated toward grounded plant
* most effective with **sub 50 micron droplets**.
* Weak force, droplets must be near canopy

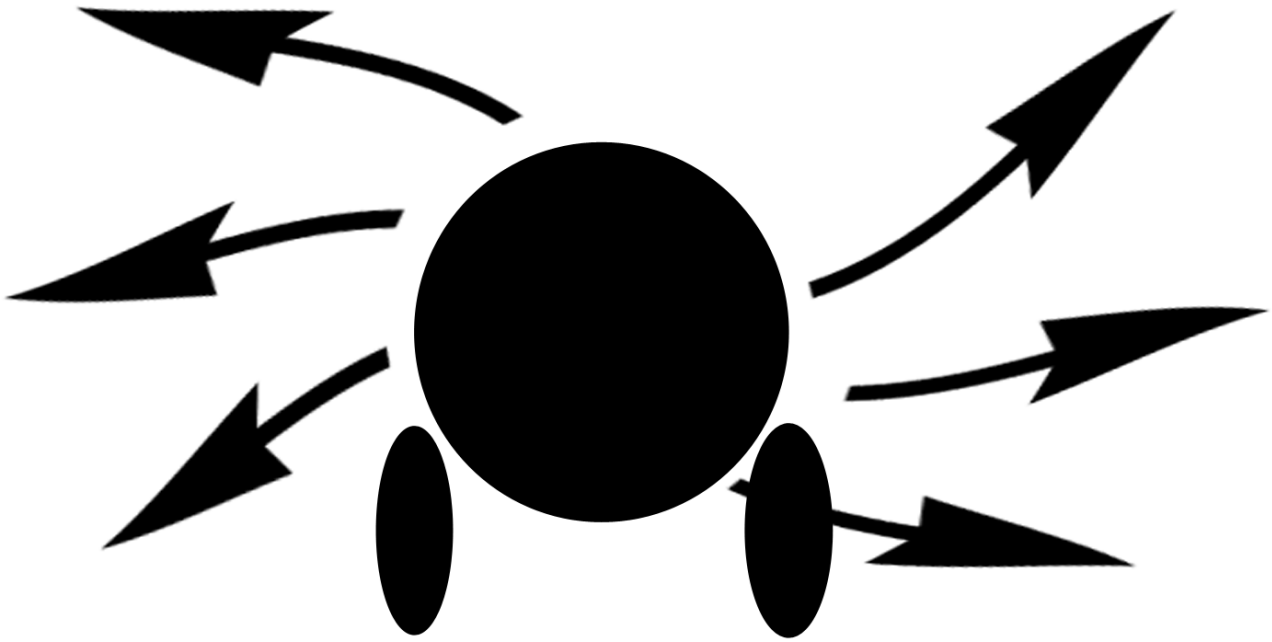
Typical Air-atomizing nozzle electrostatic sprayer

Targeting Concepts: Droplet size and air-assist radically impact underside (minimum) coverage



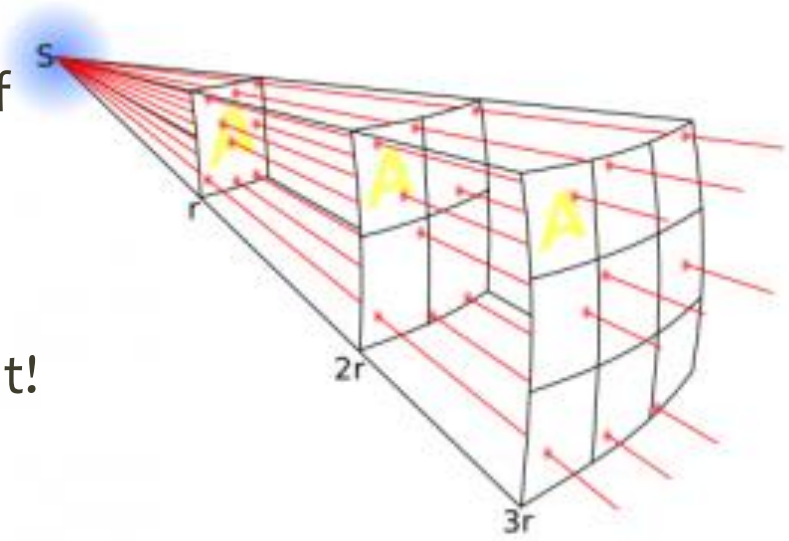
Targeting in Orchards and Vineyards: a typical airblast sprayer

* Air curves with rotation of fan- not truly radial, not good targeting or drift control



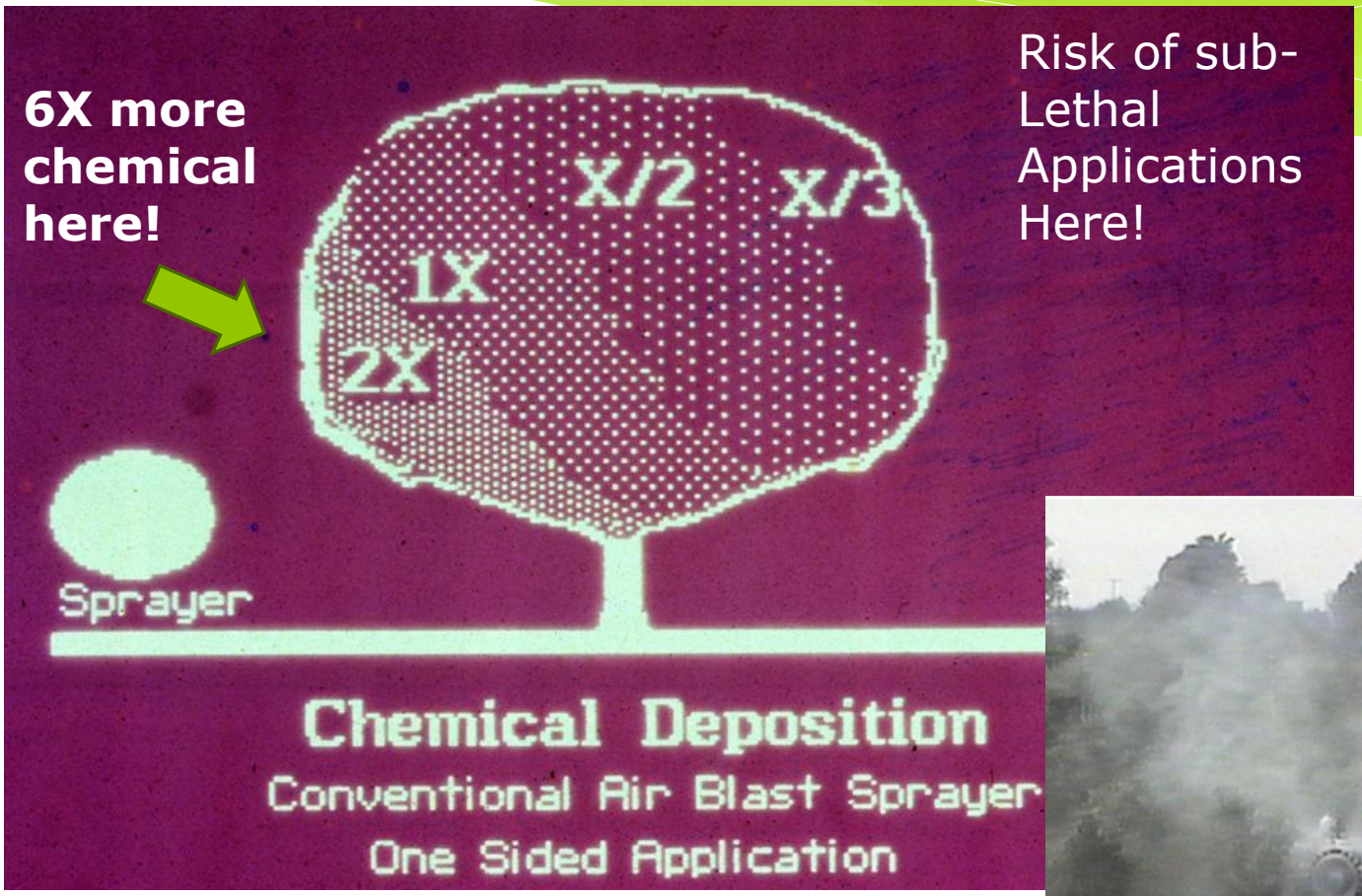
The inverse square law and air-assisted sprayers

* Twice the distance = ¼ **the air energy**
* Trying to get spray from the bottom (high energy at sprayer) to the top of the canopy (high wind energy, low sprayer energy) is very difficult!
* Adequate air energy is very important!
* Towers, towers, towers!



Conventional Radial Airblast

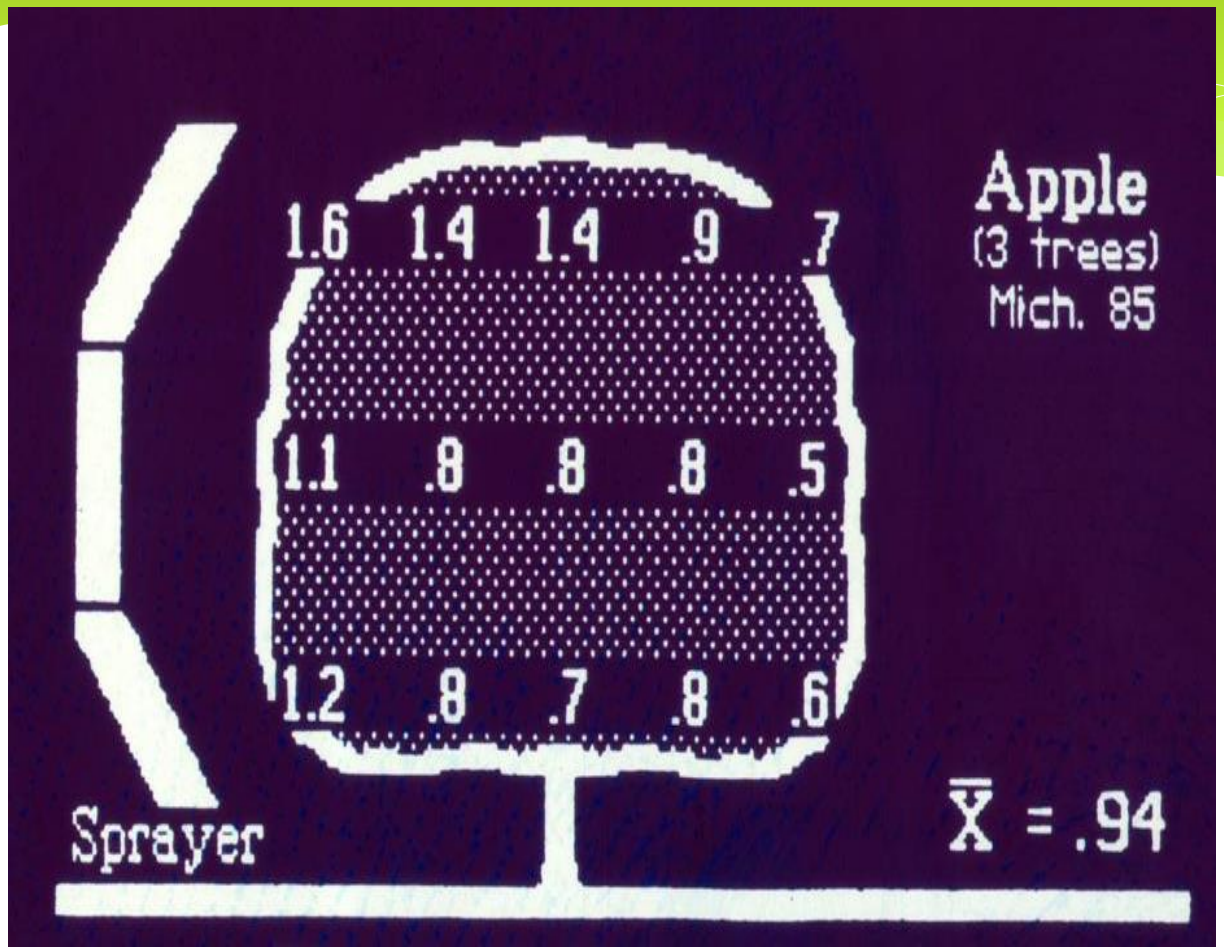
Non-targeting Sprayers: Expected Coverage Using Conventional Airblast Sprayer Technology



Risk of sub-Lethal Applications Here!

Advanced targeting: tower sprayers

Advanced targeting: targeted airflow & small droplets



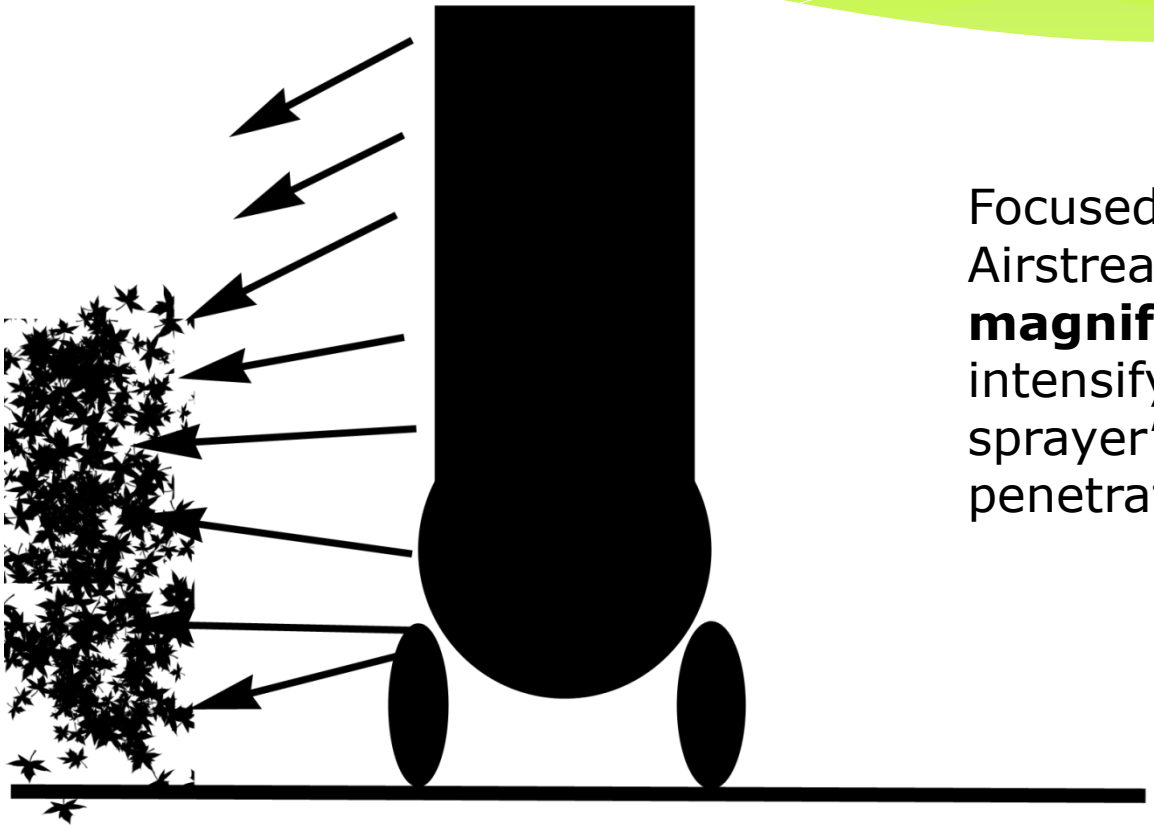
Tower type and other targeting sprayers focus air at the tree, airflow moves horizontal or downward

Coverage much more uniform

Application rates 10 to 50 gal/acre

Droplet sizes typically 50-110 micron VMD

Advanced Targeting: Focus the Air Horizontal & Down on Canopy



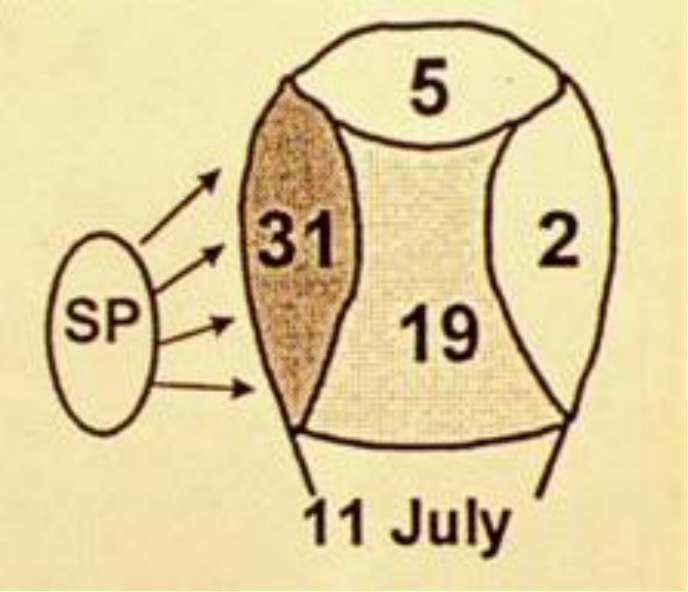
Focused, converging Airstreams are like a **magnifying glass-** intensifying the sprayer's ability to penetrate canopy

More advanced targeting: converging turbulent airflows

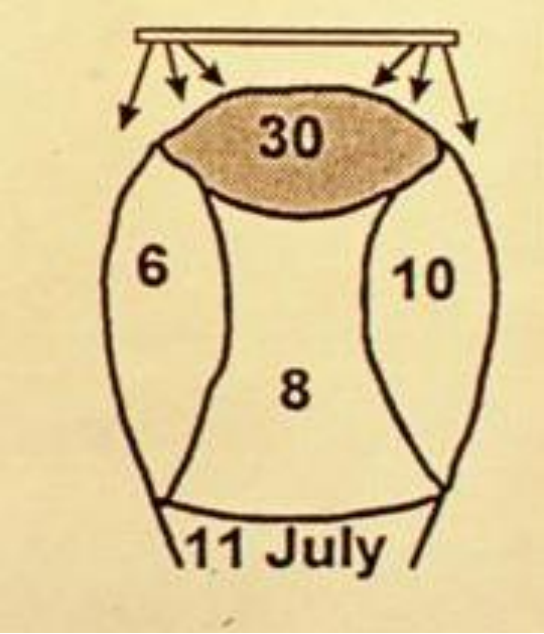
Targeted Airflow & Small Droplets

Deposition in Blueberries, % Area Covered

Conventional radial sprayer, non-targeted



Targeted sprayer :
3x *minimum* deposition



Part 2: Visualizing deposition

Can we tell the story with better metrics and methods?

* How do we visualize what we can't see normally?
* Better understanding of "least coverage" promises more robust links to efficacy, but first we have to be able to easily and affordably quantify it.

Field versus Lab?

* Sometimes it's valuable to actually be able to visualize spray in the field. So ho do we when the droplets are so small?

* Moving on to the lab, The metrics we have, each only provide a piece of the story.

    * Percent area covered
    * Hits per unit area.
    * Stain size.
    * Mass/area (leafwash)

* Each gives an incomplete measure of quality. And what about the quality of the measurement itself?

Field methodology: Visibly Fluorescing dye

Example 1: low-volume spraying in citrus

~30 GPA (300 L/Ha) at ~3 mph.
spray is barely visible in daylight,
tree dries almost instantly.

Sampling Methods, Plot Layout. Sample to be able to differentiate *minimum* coverage!

Human and physics problems

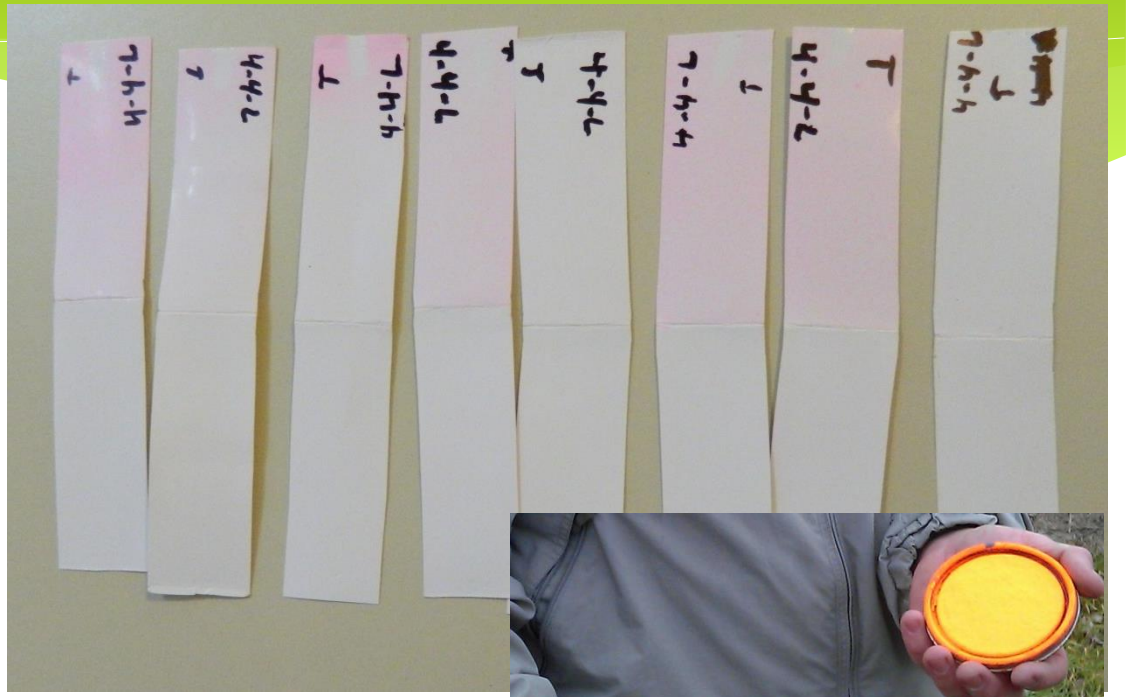
Human: I can't "see" it, it's not there….

Collection Methodology:

* "good" tracers?
* "good" collectors?
* How small do we need to see or measure trace- what's practical and possible?

Collecting Field Data

* begin with a visible dye on a “clean” background
* Kromekote or Chromalux paper collectors
* Dye options versus water sensitive paper



Remember these guys…

Human visual threshold, ~100 Micron stains,

the width of 1 human hair. Are your eyes biasing your studies?

Two-Spotted Mite: 500 Microns

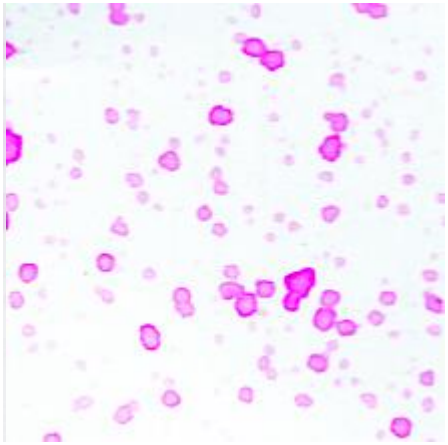
50 micron stain: a mini pizza of pure poison

Just over 1 PIXEL at 600 DPI! (1 pixel = 42 microns

Sampling Methods, Spray Cards

Below, are 2, 1 cm square Kromekote card samples after application. Color scanned at 4800 DPI resolution.

1 pixel = 5.7 microns. Tracer is red



Scan 1

Scan 2

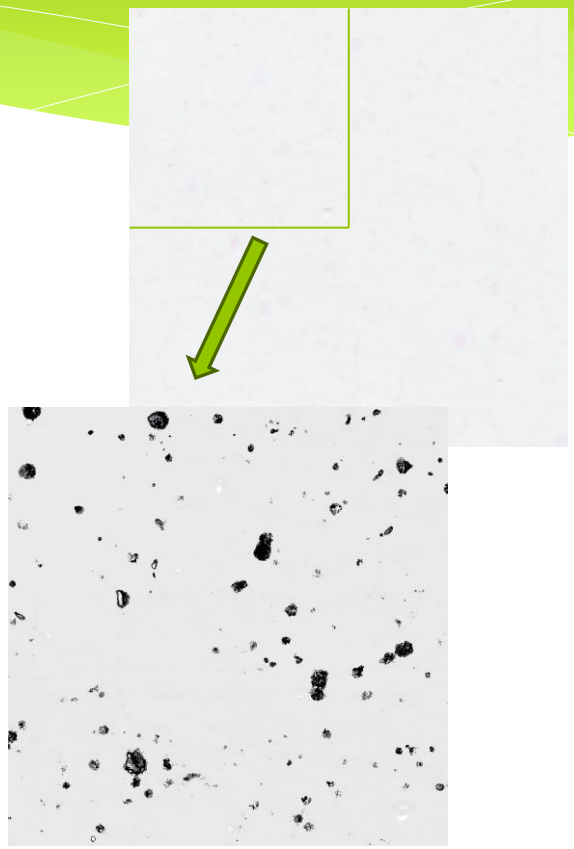
Sampling Methods, Spray Cards

At right is scan 2 from the prior slide.
A leaf wash or Mylar card wash will show low residue levels in this strata.

Is this good coverage?

At right, the upper left **.25 cm** of this same scan magnified.
Tracer digitally changed to black.
There are nearly 200 hits on this .25 cm square sample.

Now is it good coverage?



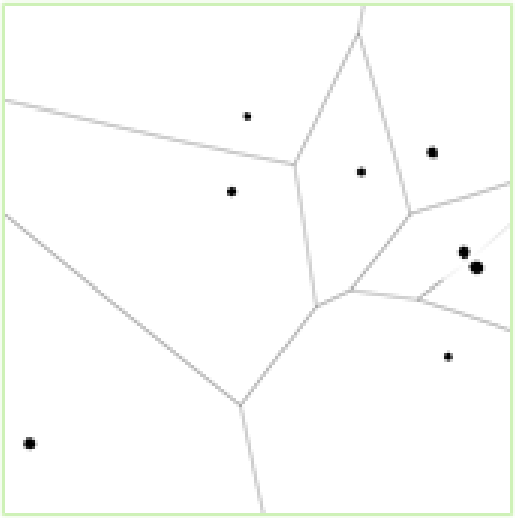
Qualitative measures: What you see:

2 cm^2 4800 DPI Scan actual resolution

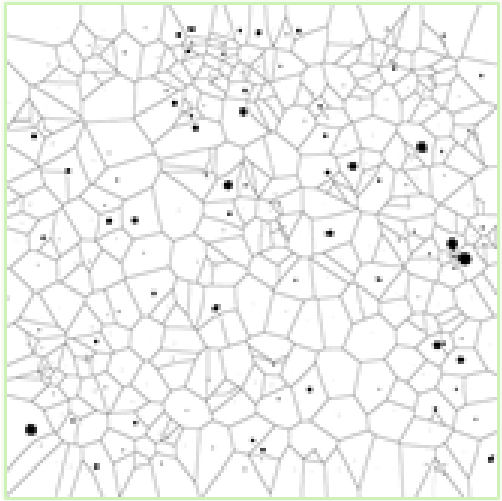
.2% black food grade dye

what the computer sees

Typical resolution scan, 100 DPI
8 hits found



Hi-Resolution Scan of *same card*
4800 DPI- 528 hits found



What the computer can see… If you let it.

Image resolution, DPI	1 pixel, microns diameter	Microns^2 per pixel	Measured hits	**Hits missed**	Total area covered	Average stain area	percent area covered	**Estimated coverage missed**
4800	5.3	28.0	528	**0%**	2896419	5485.643	0.724	0.0%
2400	10.6	112.0	377	**29%**	2888749	7662.464	0.723	0.1%
600	42.3	1792.1	158	**70%**	2750371	17407.41	0.688	5.0%
300	84.7	7168.4	68	**87%**	2437950	35852.2	0.61	15.7%
200	127.0	16129.0	53	**90%**	2308642	43559.28	0.577	20.3%
100	254.0	64516.0	8	**98%**	1048571	131071.4	0.262	63.8%

Scanning: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Mode: Professional Mode

Settings

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Destination

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Scale: 100 %

Trimming: Off On

Adjustments

Reset

Unsharp Mask

Preview | Scan

Help | Configuration... | Close

Preview

Normal | Thumbnail

Zoom

Marquee

16

All

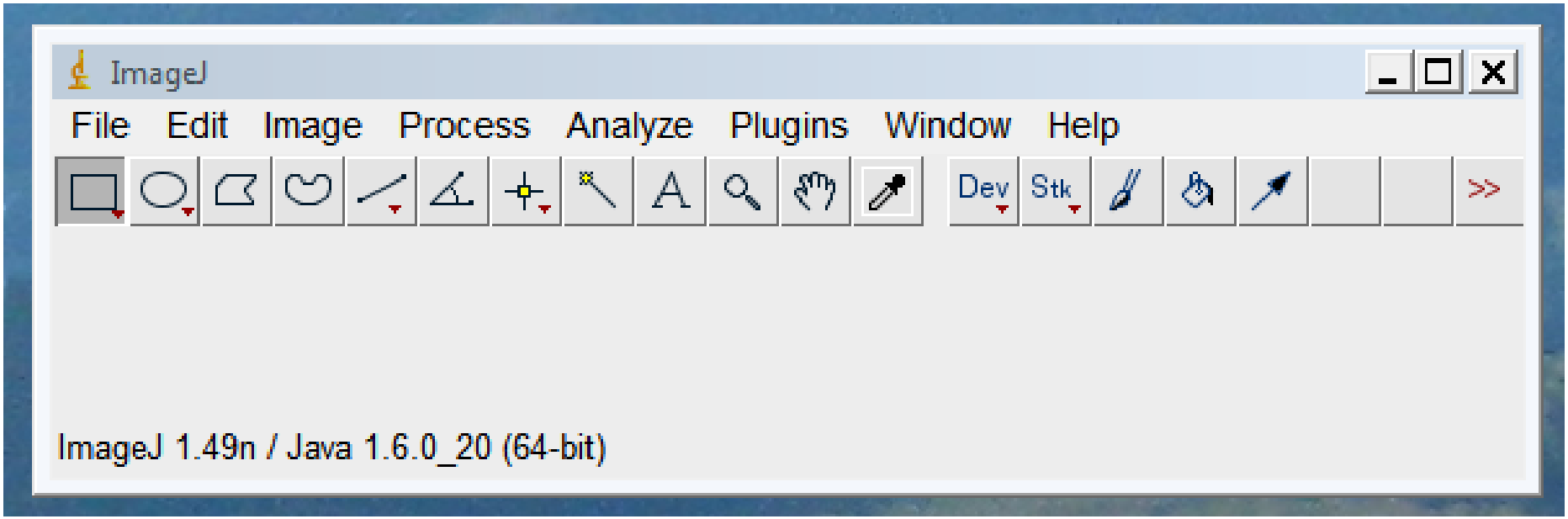
Rotate

0.79 in. 0.79 in. | 3779 x 3779 pixels 40.85 MB | R: G: B:

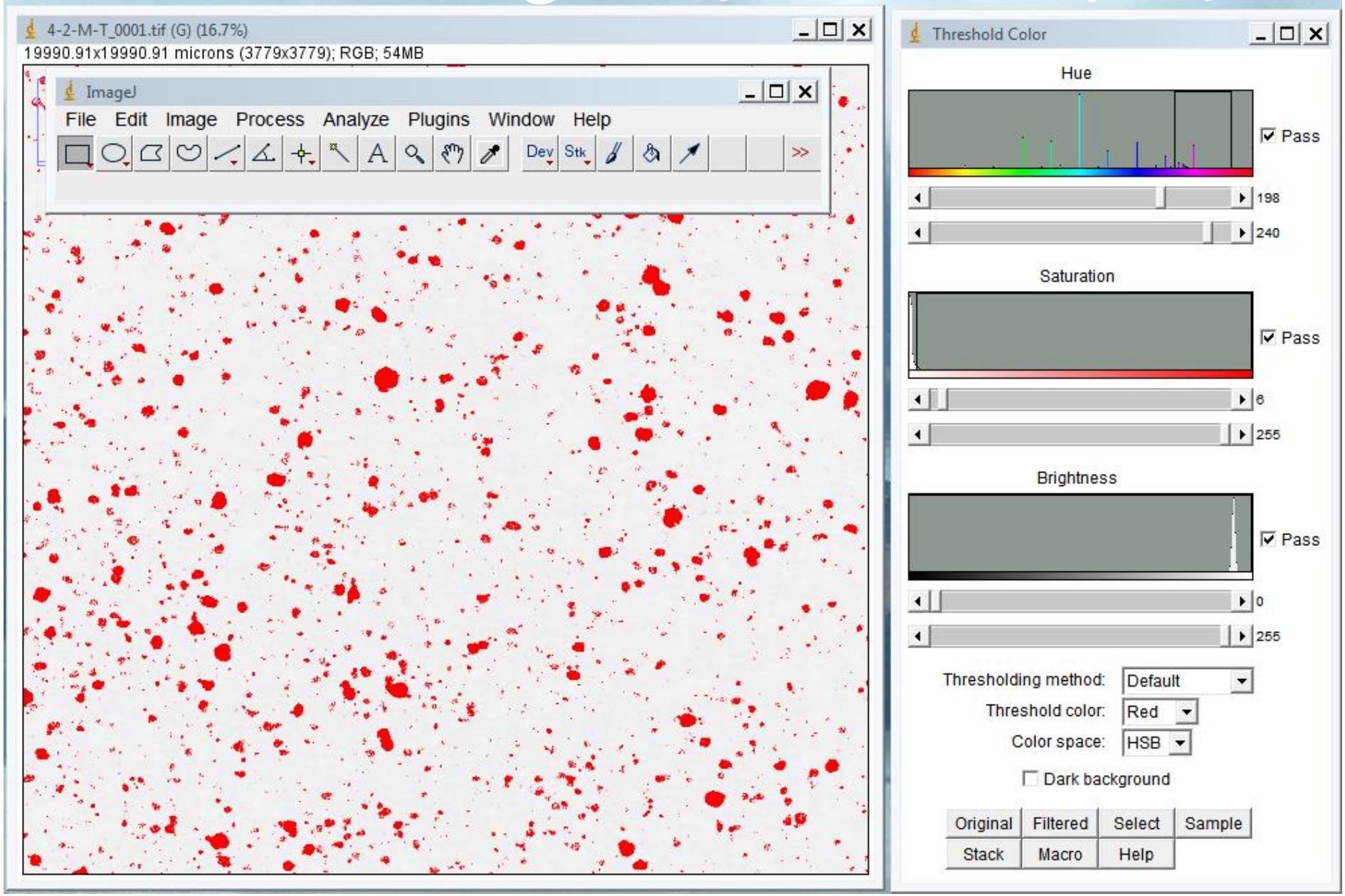
ImageJ

Produced and maintained by US National Institutes of Health

Freeware and open-source , over **1200 developers** actively contributing



Thresholding: only see the spray.



smalldropsprays.info

Search this site

Exploring affordable, simple, high-resolution imaging methods for spray deposition analysis of very fine and smaller droplet spectra, and freeware software tools to analyze them.

Contact:

Telephone (USA):
517-202-6839

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Home

Welcome to **smalldropsprays.info**

This site's purpose is to provide simple, useful information on **gathering and analyzing qualitative deposition data for small droplet spectra**. You will find enough methodological detail here to design an experiment, execute, and analyze spray deposition including droplet stain diameters as small as **5.3 microns**. This is highly useful in understanding high hit number, low percent cover deposition such as on this 2 centimeter square card, magnified and enhanced (below at left):

Affordable and fast:

If you already have the appropriate scanning equipment and tracers, you can be analyzing data within a couple of hours using these methods. If not, you will find guidance here on tracer, collector, and scanner selection, and you should be able to get all these things in a couple of days. Your total hardware investment in collectors, tracer, and high- resolution scanner will be *several hundred dollars or less.*

Help develop this methodology!

As with all science, evolution and advancement are continuous, and there are often many ways to the solution of a problem. This site includes fundamentals and basic methods. Some of you have advanced well beyond this no doubt. Help evolve this methodology by contributing your insight and experience. Disagree with something? Disputes are welcome as well. Contact information is at left below.

This effort was initially funded by the generous support of following members of the Spray Equipment Research Group- International (SERG-I): The Province of Newfoundland and Labrador, Forest Protection Limited, SOPFIM-Province of Quebec, The Province of Manitoba, and Winfield Solutions, LLC.

If you want something a bit easier ..

United States Department of Agriculture
Agricultural Research Service

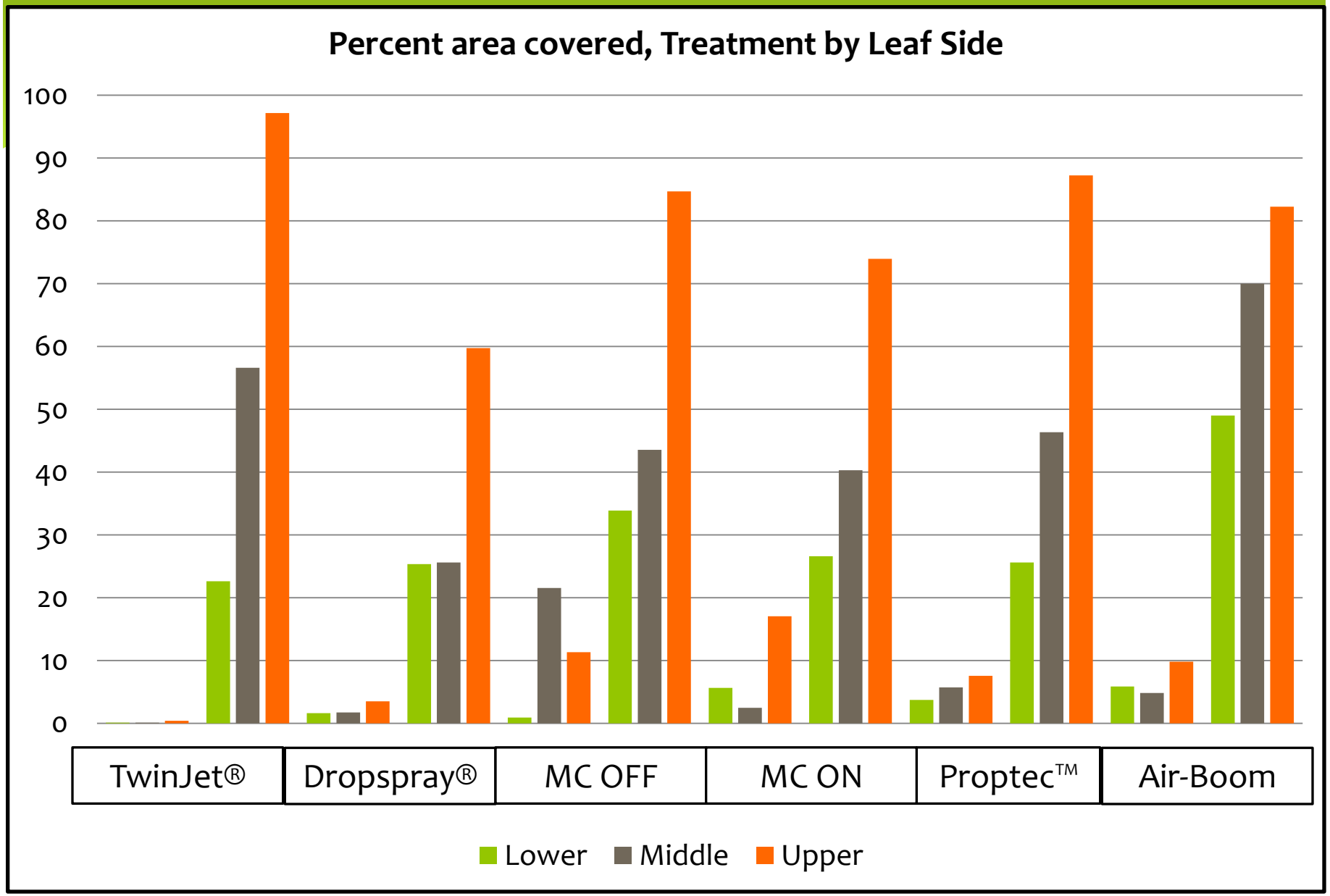
DepositScan

ImageJ based freeware
Better data handling output
Good to 2400 DPI resolution scans
Widely used worldwide

Wash (quantitative) pitfalls

* Leaf adsorption and absorption of tracers:
  * Recovery efficiency often lower with very low trace
  * Many tracers chemically “sticky”
* Adequate sensitivity:
  * Make sure the tracer is linear enough that if you had 1/100 of full coverage, you can still find it.
* Sampler recovery: Natural surfaces often very poor samplers
  * Consider alpha cellulose (filter paper) , mylar, or other plastic films

What you can see when you look more closely



Discussion and Questions?

Thank you!

Greg Dahl and Lillian Magidow, Winfield Solutions, LLC

NAICC

Emily Shepard, ABC Labs

Dr. Tom Wolf

Dr. Andreas Herbst

Dr. Andrew Hewitt