

Spraying May be Effective, but it Sure Isn't Efficient

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Factors affecting spray delivery to the tree...

- Sprayer characteristics
 - air volume + velocity
 - nozzle type
 - fan type and location
- Tree characteristics
- Spray droplet size



Typical Losses From an Airblast Sprayer

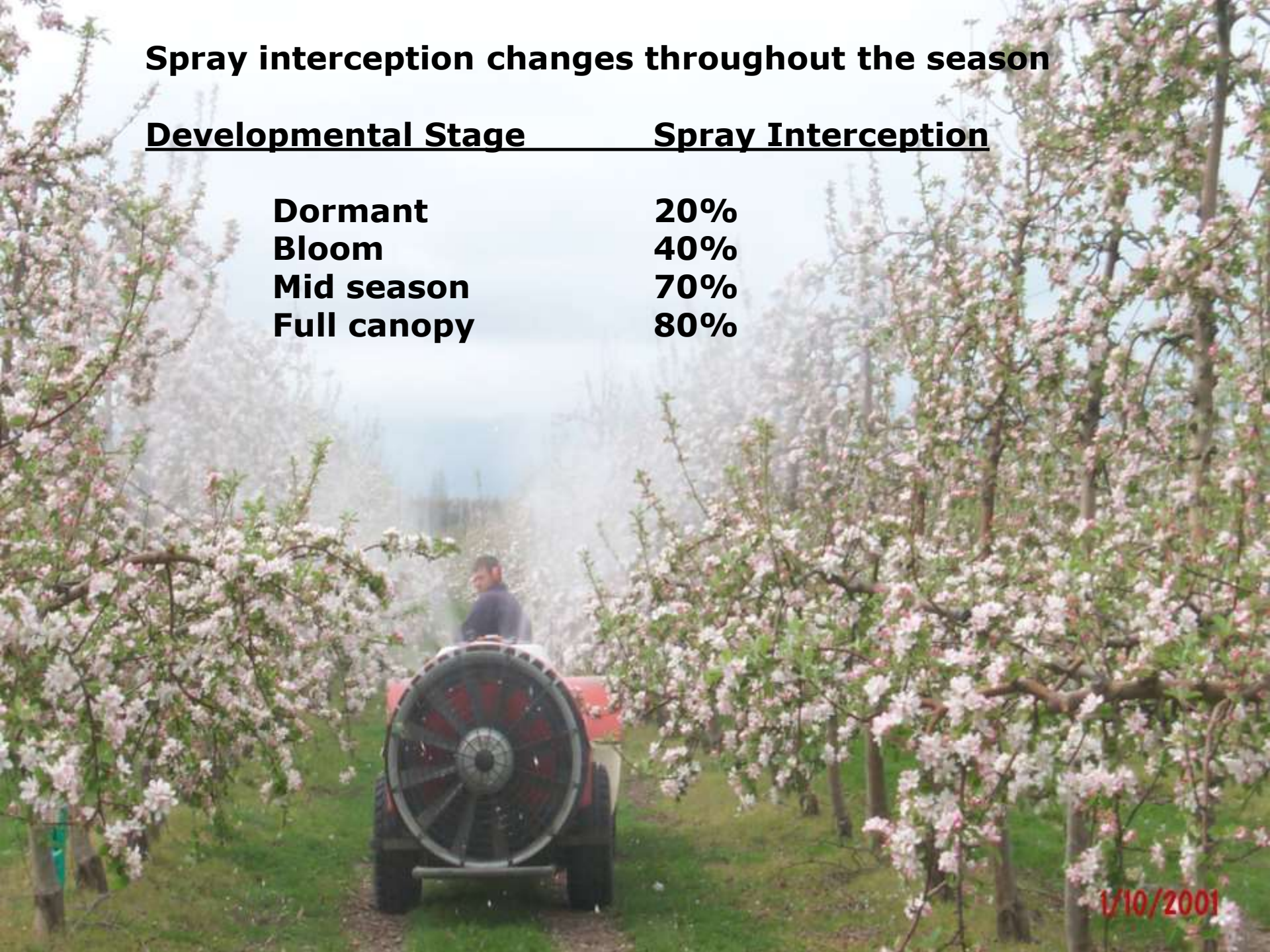
Source	Loss (%)
Evaporation	
Drift	
Ground	
On Target	

Source: Application Technology Group, NYSAES, Geneva, NY

Spray interception changes throughout the season

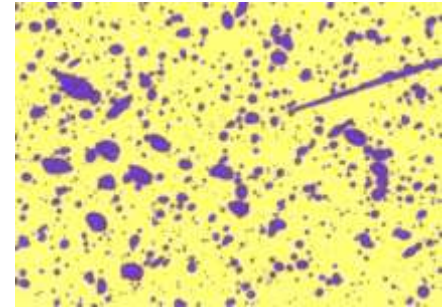
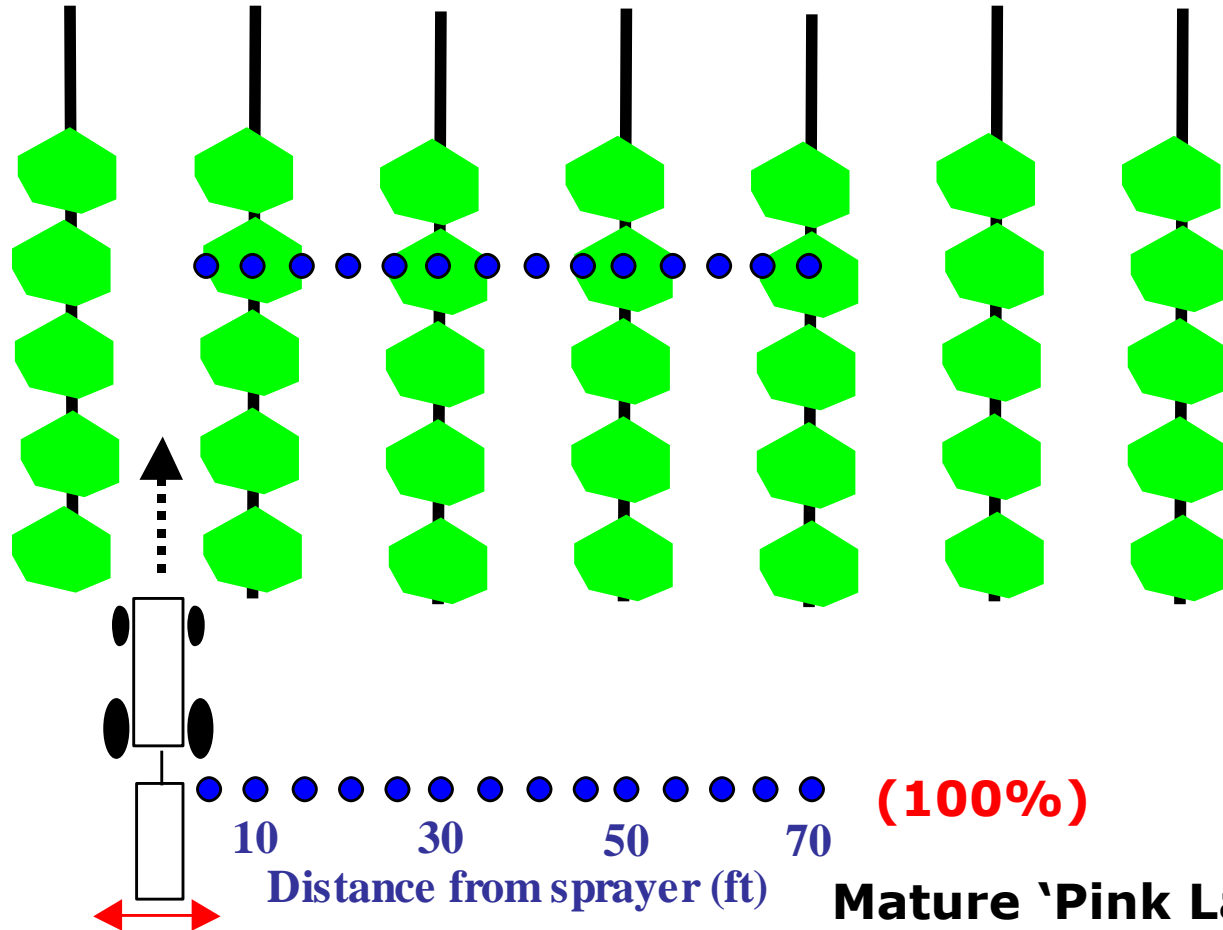
<u>Developmental Stage</u>	<u>Spray Interception</u>
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Dormant	20%
Bloom	40%
Mid season	70%
Full canopy	80%



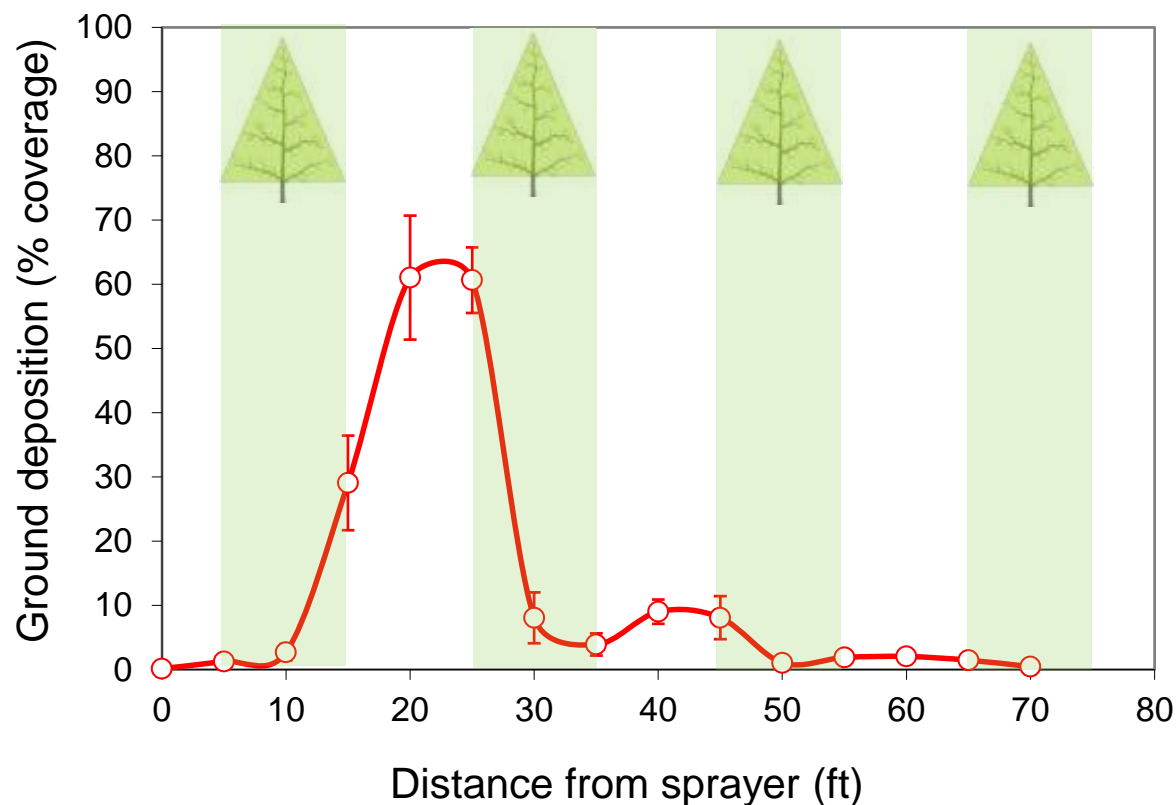
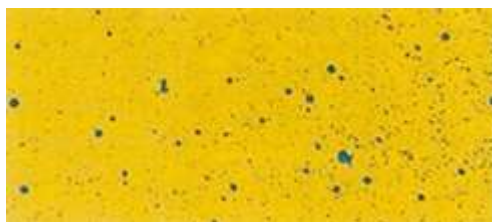
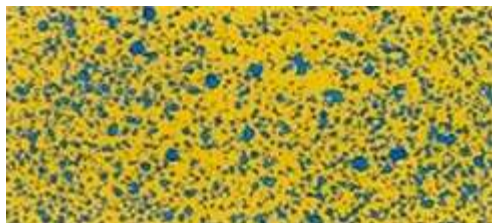
1/10/2001

Just How Much Spray is Deposited on the Orchard Floor?



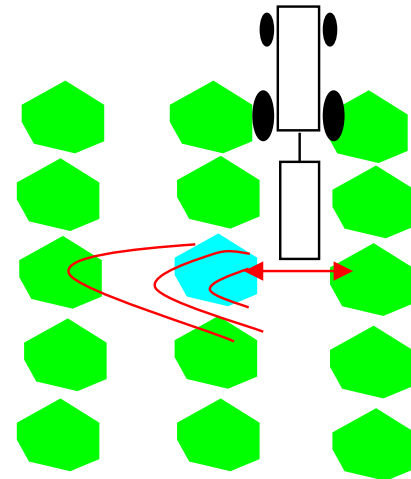
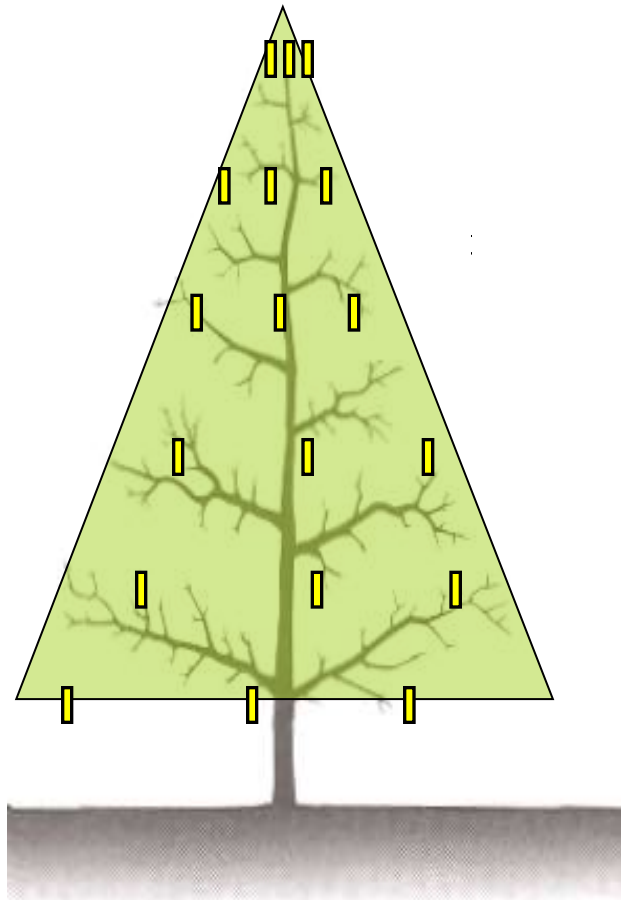
Mature 'Pink Lady'/M.7 orchard
20 ft × 10 ft
Air blast sprayer
160 gallons per acre
Measured at time of thinning

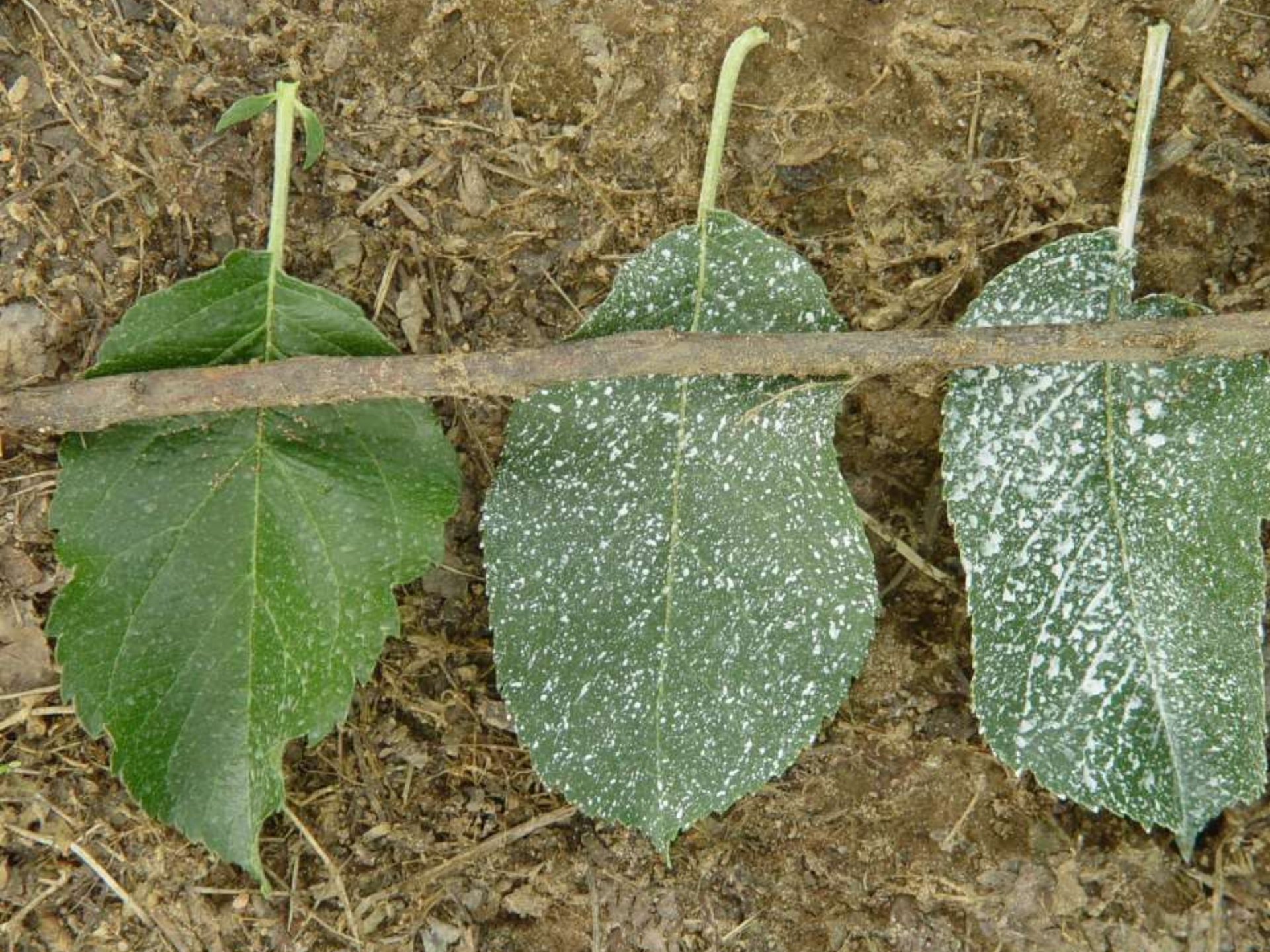
Ground Deposition of Spray in a Mature 'Pink Lady'/M.7 Orchard Around The Time of Thinning



74 % of the Total Spray Volume Ended up on the Ground!

Spray Interception Does not Account for Differences in Spray Coverage Throughout the Tree Canopy

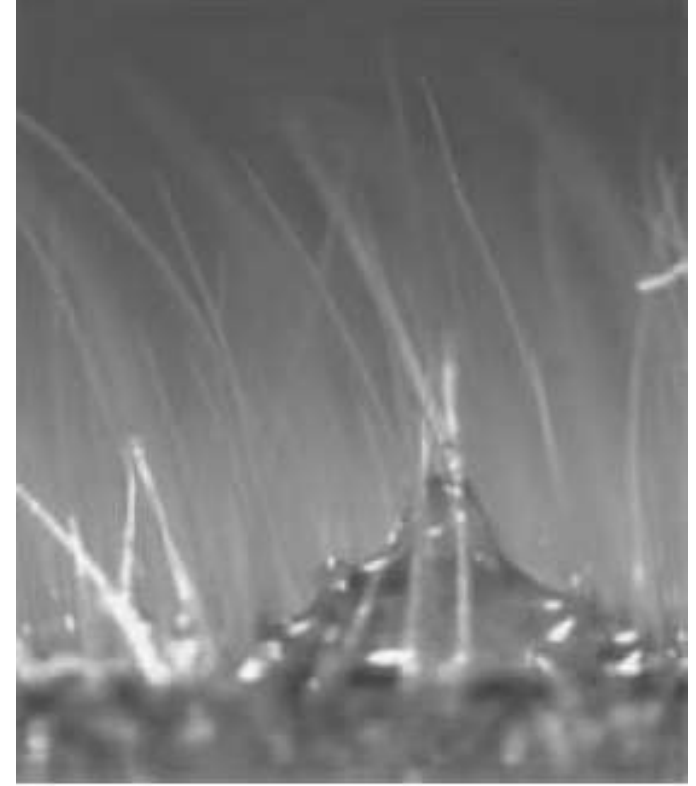
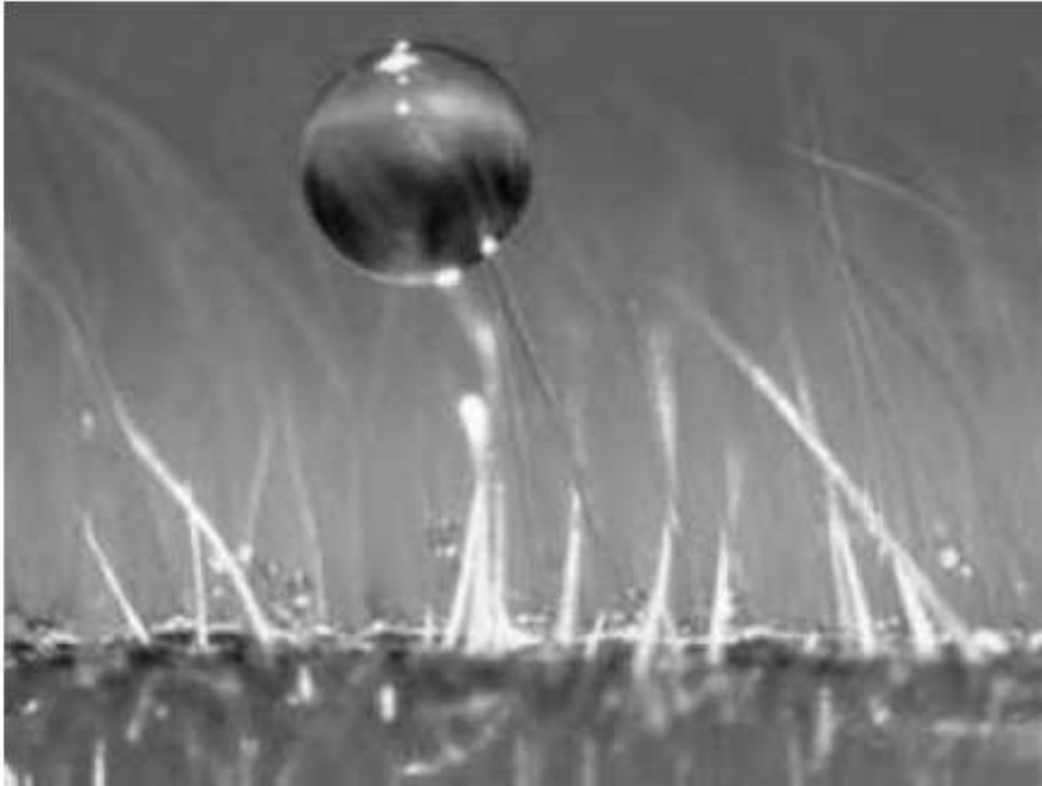




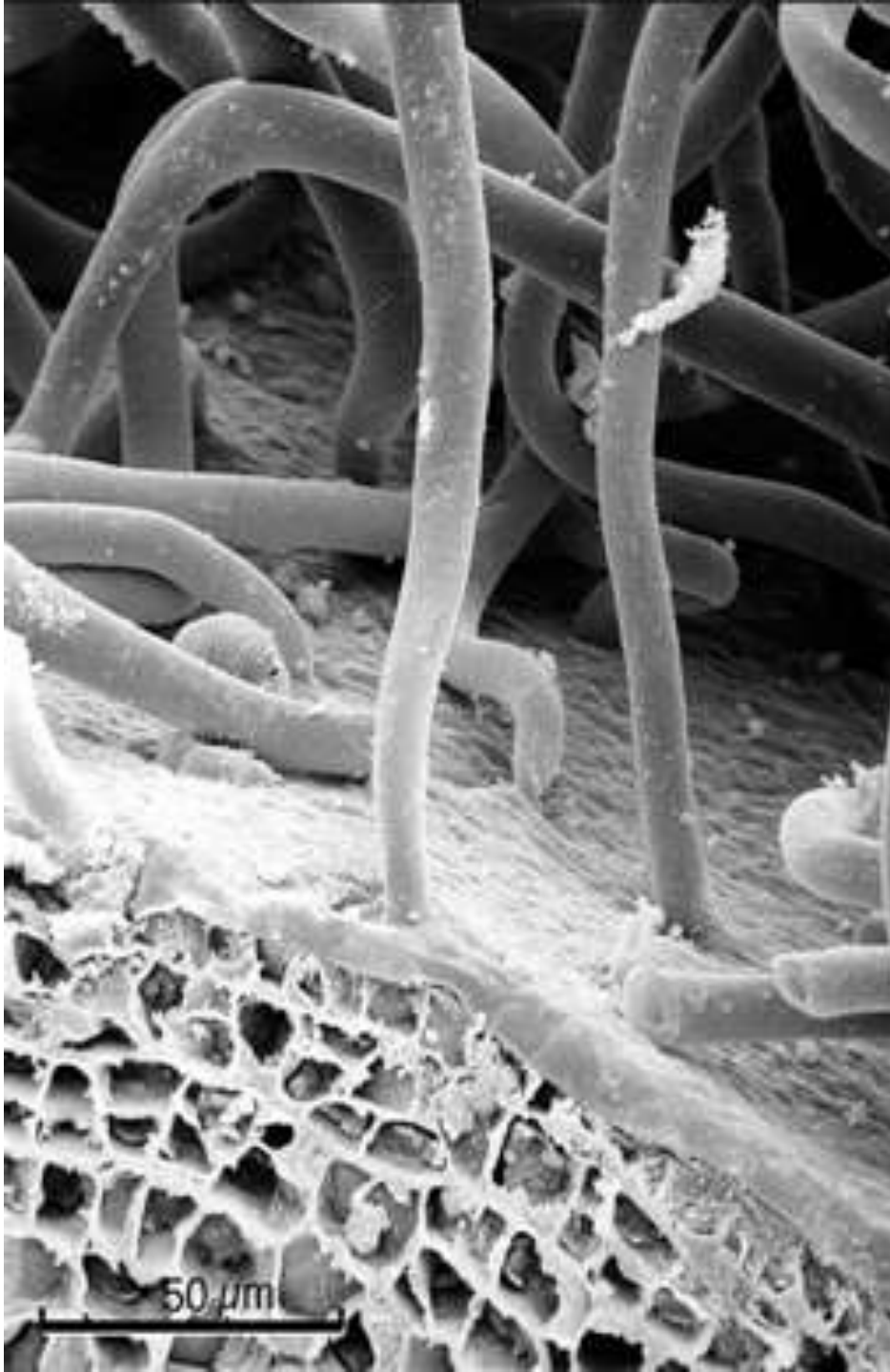




Tiny Hairs called Trichomes are a Barrier to Spray Penetration



Spray droplet on a hairy Pelargonium leaf without (left) and with (right) a surfactant

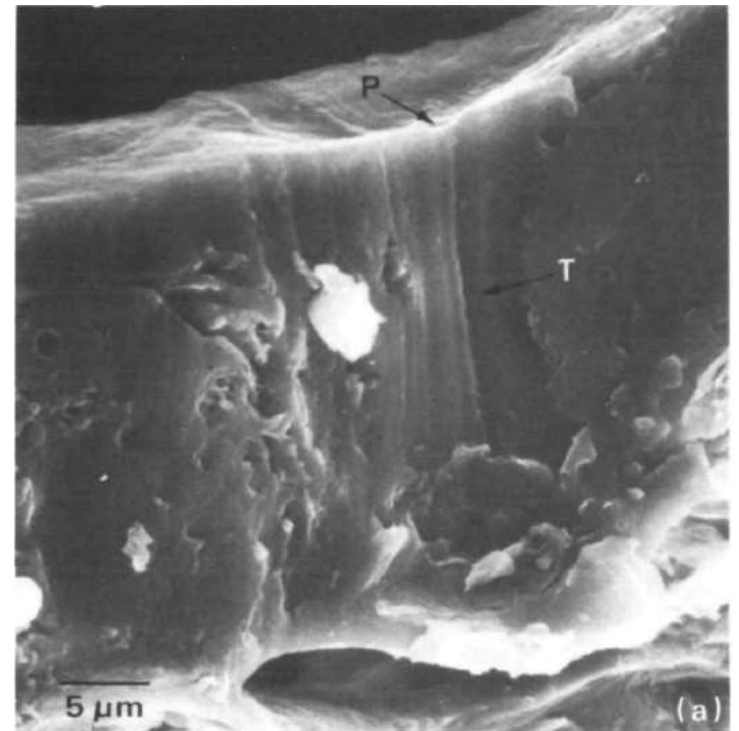


Epidermis and cuticle of young 'Gala' apple fruit, 7 days after anthesis (left)

Source: Martin Goffinet

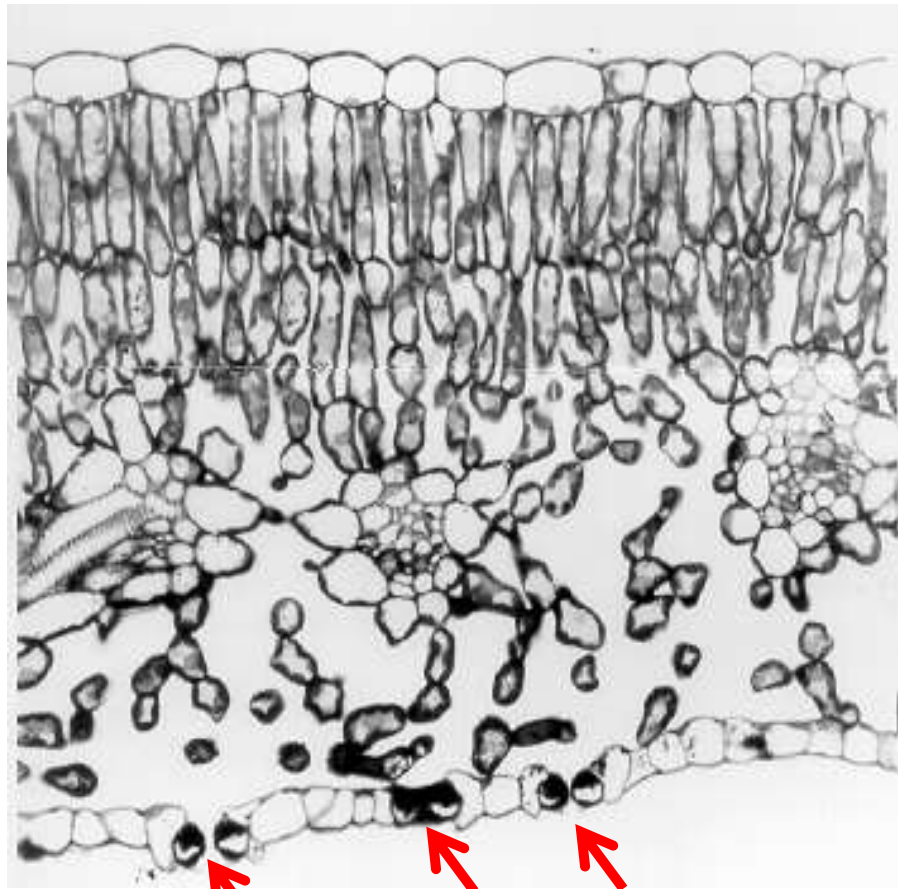
Dewaxed cuticle of apple fruit (below)

Source: R.H. Miller (1982). Ann. Bot.





Rapid relative fruit expansion rates during the first few weeks after bloom can generate stress-fractures in areas where the cuticle is weak



stomata

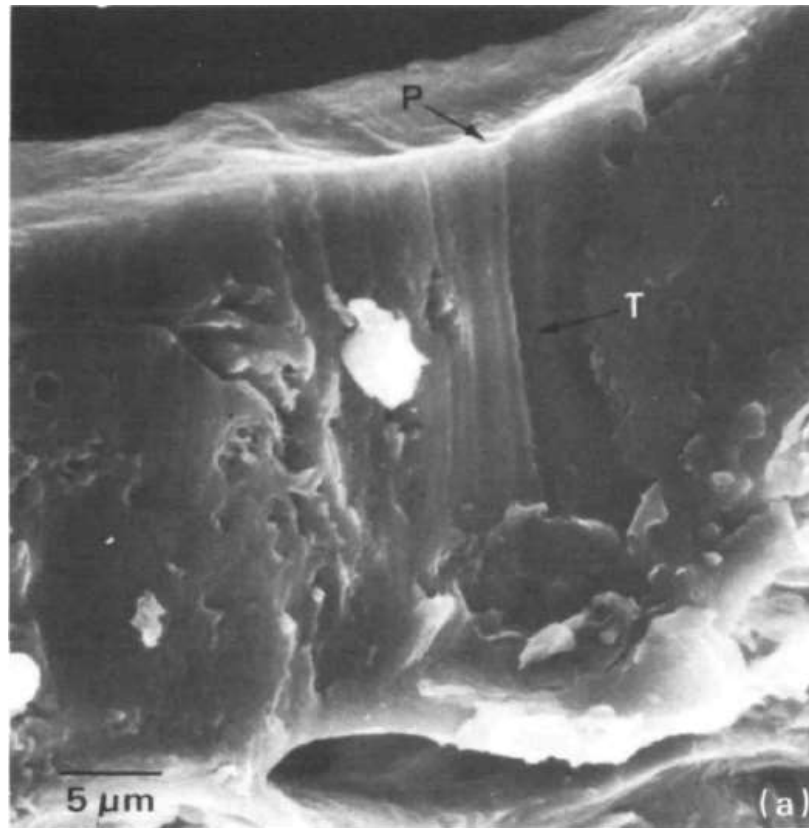
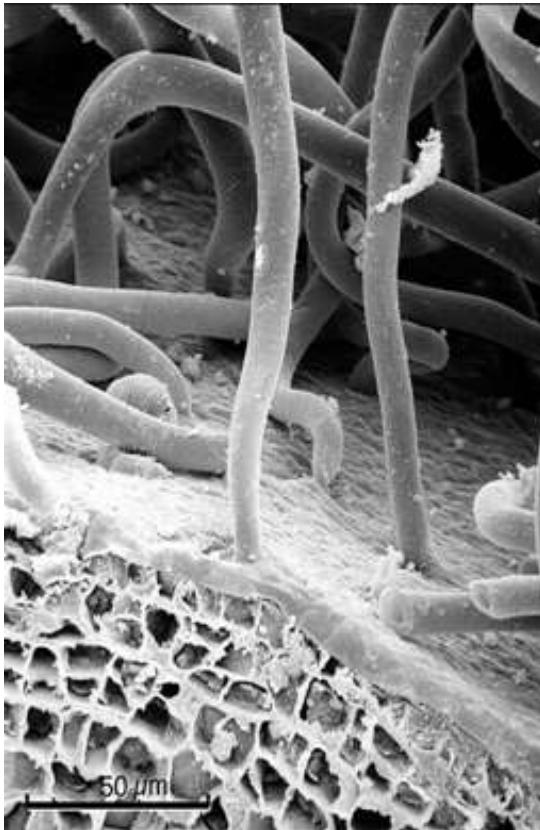
300-500 stomata/mm²

**Cross-section through
an apple leaf**



There are two possible pathways through the cuticle...

- **Lipophilic pathway**
- **Hydrophilic pathway through aqueous pores**



What Role Does Droplet Drying (and re-wetting) play in Chemical Uptake?

Humectant increases uptake of calcium into apple fruit (Blanco et al., 2010)

- Addition of carboxymethyl cellulose (0.05%) to the CaCl_2 spray solution
 - **Slowed droplet drying**
 - Increased calcium levels in the skin and cortex
 - Reduced bitter pit in storage



Characterizing Penetration of Aminoethoxyvinylglycine (AVG) through Isolated Tomato Fruit Cuticles

M. Knoche • P. D. Petracek

J Plant Growth Regul (2013) 32:596–603

DOI 10.1007/s00344-013-9327-7

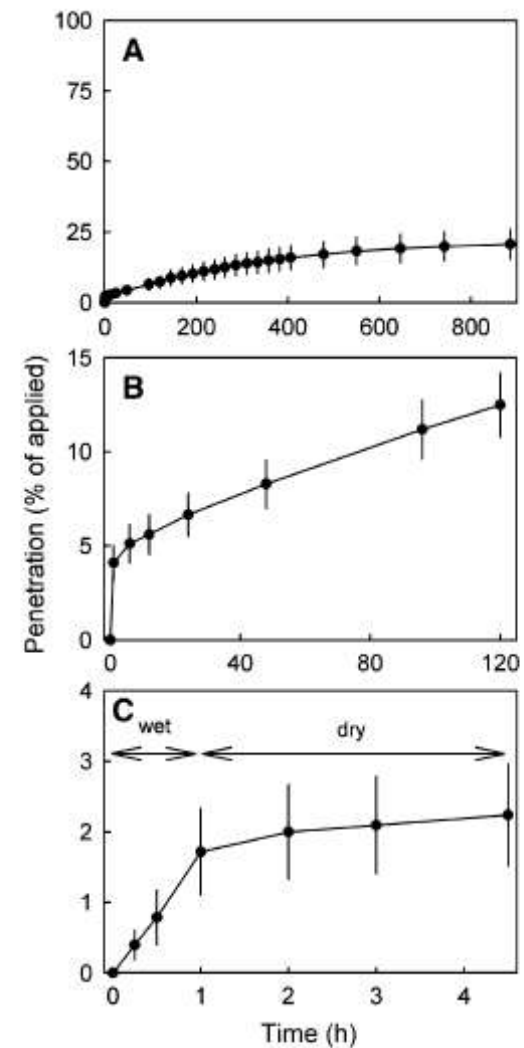
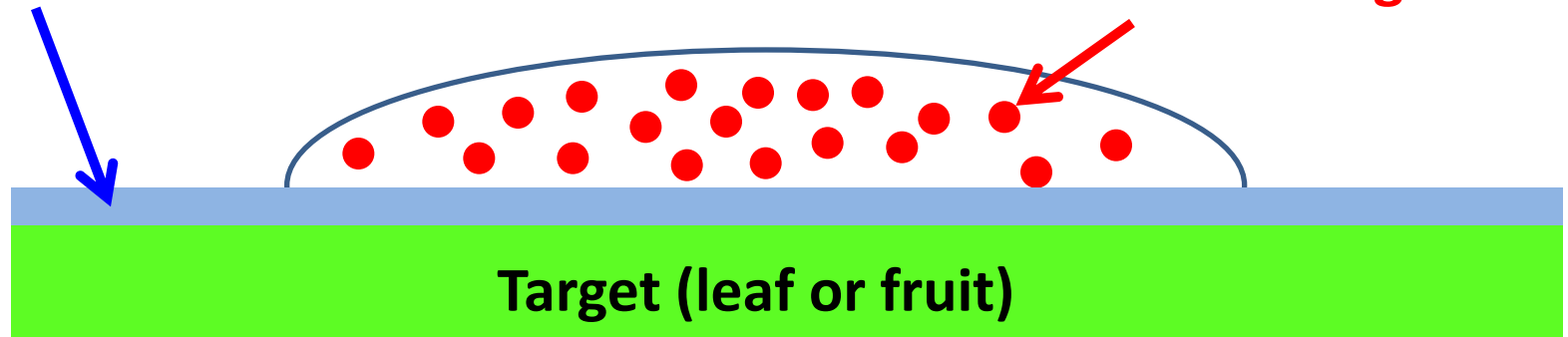


Fig. 1 Time course of aminoethoxyvinylglycine (AVG) penetration through isolated tomato fruit cuticles **a** long-term (more than 1 month), **b** middle-term (5 days), **c** short-term (less than 5 h) time course of AVG penetration

cuticular matrix

active ingredient



Both droplet contact area and drying time will influence uptake

Wash-off of the dried residue can be significant

Chemical

Losses

Mancozeb

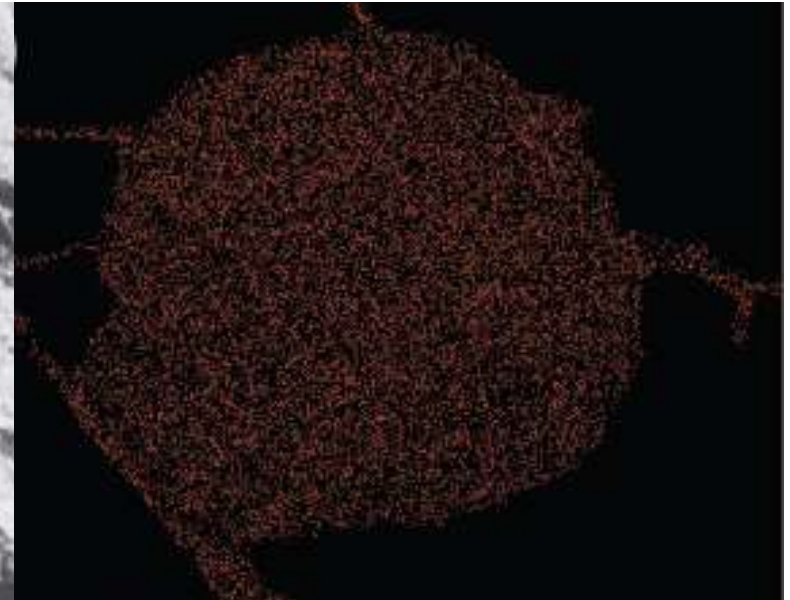
- 5 mm (0.2") light rain (0.5 mm/hour) 50%
- 5 mm (0.2") torrential rain (1.9") mm/hour) 90%

Captan

- dry 1% per day
- 1 mm (0.04") rainfall 50%

Calcium chloride (unformulated)

- 5 mm (0.2") heavy rain (5 mm (0.2")/hour) >70%



Bukovac (2005)

Classes of Spray Adjuvants

Acidifier	Emulsifier
Activator	Evaporation reduction agent
Antifoaming agent	Extender
Buffering agent	Humectant
Canopy penetrating agent	Penetrant
Compatibility agent	Spreader/wetting agent
Deposition aid	Sticker
Drift control agent	Surface active agent (surfactant)

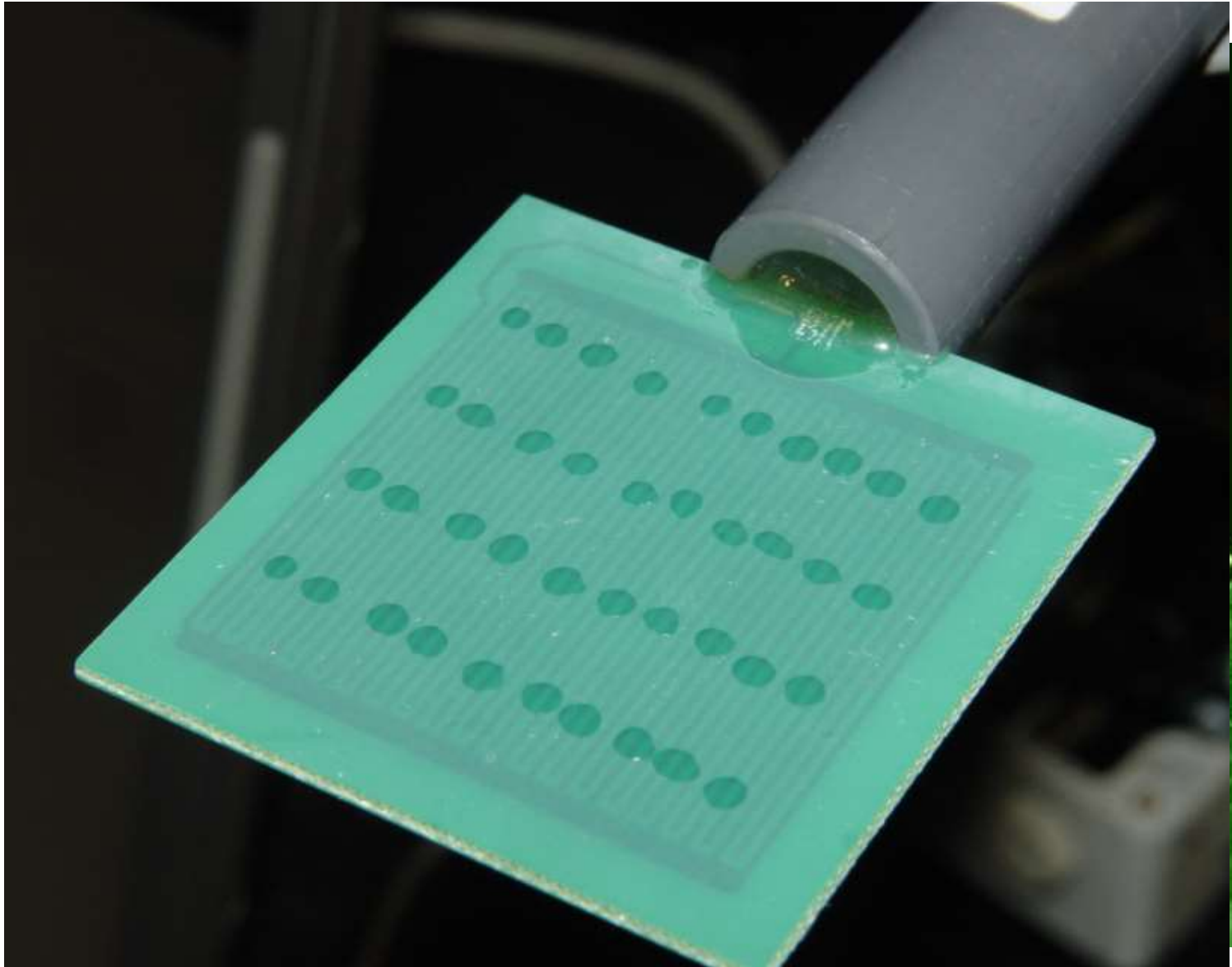
Humectants absorb and hold water, slow down drying of the droplet

Penetrants help the active ingredient move through the cuticle faster

Surfactants lower the surface tension of the liquid, helping droplet spread

Product	Manufacturer	Classification	Active ingred.	Concentration
Hum-AC 820	Drexel	Humectant/surfactant	Glycerol Alcohol ethoxylate Polyoxyethylene-polyoxypropylene monobutyl ether	16 oz/100 gal (0.125%)
Vader	Loveland	Penetrant/acidifier/ deposition aid <i>"formulated for neonicotinoids"</i>	Phosphatidylcholine Methylated vegetable oil Alcohol ethoxylate	32 oz/100 gal (0.25%)
HiWett	Loveland	NI organosilicone surfactant Super-spreader <i>"Lowers surface tension of spray solution well below commonly used surfactants <u>but does not promote high levels of stomatal infiltration which can cause plant damage.</u> Especially suited to low volume spraying i.e., 25% or less of normal water volume"</i>	Polysiloxane polyether copolymer Alcohol ethoxylate Polyoxyethylene-polyoxypropylene copolymer	4 oz/100 gal (0.03%)

How Can You Measure Droplet Drying Times?





A Simple Math Problem



\$100



Dormant: 20% interception \$20

Bloom: 40% interception \$40

Mid-season: 70% interception \$70



Penetration: 15% of a.i. \$6



Critical Components of the Spraying Process

- Orchard design
- Spraying technology
- Chemistry



1/10/2001