PRINCIPLES OF HEAT STRESS REDUCTION AND LIGHT ENHANCEMENT IN ORCHARDS USING REFLECTIVE MATERIALS

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What is a 'Particle Film'?



• A microscopic layer of mineral particles

 allows water and carbon dioxide to pass through the film

Stomates are not blocked After initial application After 24 hours









Reflective surfaces are common plant adaptation

- Plants "use" pubescence and cuticular waxes to reduce environmental stresses and reduce disease and insect damage
- Particle film technology builds on this strategy of a reflective plant surface that repels insects

Particle Film Technology

- Based on a chemically inert mineral, Kaolin. Used in paints, plastics, cosmetics, pharmaceuticals,food.
- •Registered with EPA in 1998 as "Surround" for insect control.
- •Exempt from Tolerance and is approved for organic use with a 4 hour REI.

• Surround WP is used in conventional (85%) and organic (15%) fruit production; valuable for transition from conventional to organic crop production.

Particle Film Technology

Multi-functional Tool for Agricultural Production

- <u>Reduced Insect Damage</u>
 - –Protection against insects in a wide range of crops
- Horticultural Benefits
 - -Sunburn reduction
 - -Heat stress reduction
 - »Increased photosynthesis
 - »Decreased water stress
 - -Improved fruit quality
 - »Improved fruit color

• Particle Film Development

• First Spray

• Second Spray

• Third Spray



•Mechanisms that reduce sunburn damage

1) Reduced temperature
2) Reflection of IR
3) Reflection of UV
4) Reduced visible light

Fruit temperatures demonstrate infrared reflection and temperature reduction



AUG 99 INFRAMETRICS 760 LW 12:52:10 +28.2°C COLOR ON TME=00:03 EL T





The processed kaolin is highly reflective of all UV wavelengths



Uv-A and Uv-B Radiation

Visible Radiation

Radiation levels at solar noon



Sunburn damage (%)



	Wenatchee, WA	Nelson,
	USA	New Zealand
Surround-WP	2	1
Untreated	11	22

Generally, sunburn is reduced approximately 50% or more

Aerial Application of Surround WP to Bananas for Sunburn Control in Honduras



How do particle films alter light transmission and scatter?

Laser on glass

Laser on particle film







Mean fruit weight (g) Control 110 b Surround 117 a

Whole Canopy Photosynthesis 2003



Hour

Photosynthesis is fundamentally limited by 2 factors:

- Carbon dioxide levels within the leaf
- Light reaching the leaf surface
 - Particle films reduce light (5-10%) but increase internal leaf carbon dioxide.
 - The balance between these 2 limiting factors determines if photosynthesis will increase or decrease.

Transmission of PAR through particle films of various kaolin sources.



Effect of particle film on carbon assimilation in apple and internal carbon dioxide concentration



Effect of Surround-WP on fruit weight (g/fruit) of 'Empire' apples

Treatment	1998	1999	2000	2001
Surround WP	117 a	164a	124a	134a
Control	105 b (0.12)	139b	116b	131b (0.09)

Treatment	2002	2003	2004	2005
Surround WP	144	117a	170a	138a
Control	144 ns	110b	153b	123b

Effect of 'Surround' on fruit color (2005)



Control

Surround 3% Surround 12%

Increased light scatter within the plant cahopy

Reflection of light from the orchard floor





Light levels in an apple orchard



Effect of Mylar film and particle film on 'Empire' apple color development Fruit weight

Treatment	(g)	hue°
Control	131 b	72a
Control+ ground particle		
film	136 a	60b
Aluminized plastic	132 b	63b

Lower hue angle indicates increased red color

Amount and quality of light reflected from grass, reflective particle films and an aluminized reflective plastic film.

Treatment	Reflected photosynthetically active radiation	Ultraviolet radiation (315 to 400 nm)	Red/Far Red ratio (660/730 nm)
	(% of inco	oming)	
Grass	5.1	2.0	0.12
FTKS	10.7	8.1	0.38
GCO	11.1	8.0	0.37
Reflective film (new) ^z	65.5	56.9	1.27
Reflective film (old) ^y	49.3	46.8	1.13
Full sunlight			1.33

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- The Particle Film improves red color development in the unexposed surfaces of apples
 - Site and region specific
 - Cultivar specific

Successes of Particle Films

Insects	<u>Crops</u>
Pear Psylla	Apple
Pear Rust Mite	Pear
Apple rust mite	Peach
Codling Moth	Cherry
Leafhoppers	Almon
Plum Curculio	Walnu
Apple Maggot	Pecan
Thrips	Grape
Leaf Rollers	Berries
Japanese Beetle	Corn
Mediteranean Fruit fly	
Olive fruit fly	Olive
Glassy-Winged Sharpshooter	Citrus
Rhieberry Maggot	Melons

<u>Summary of Particle Film Technology</u> Multi-functional tool for agricultural production

- Horticultural Benefits
 - Sunburn reduction
 - Heat stress reduction
 - » Decreased water stress may improve fruit quality and yield
 - Improved fruit quality
 - » Improved fruit color

- Reduced Insect Damage
 - Many classes of insects are repelled in a wide range of crops

- Potential Obstacles to Use
 - Washoff of mineral residues from fruit
 - Washoff by rain and wind
 - Interference with biological control