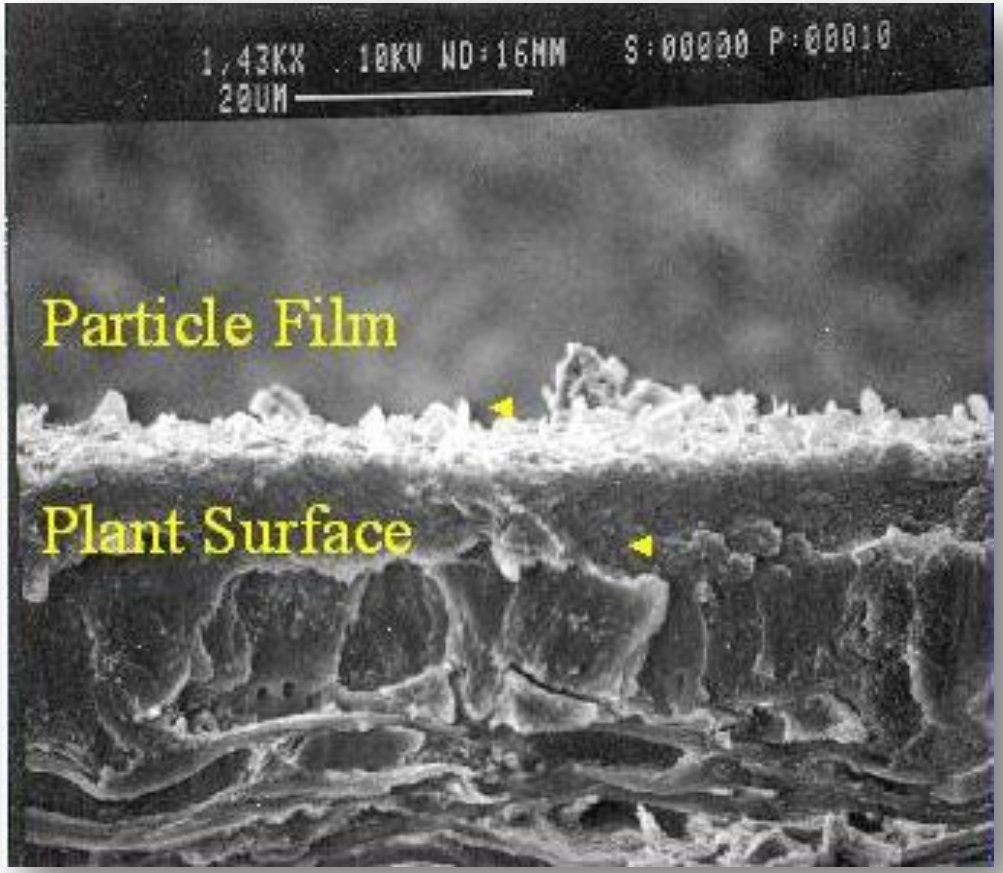
Particle Film: A New Technology for Plant Protection and Postharvest Quality Improvement in Apple

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R.R. Sharma
Principal Scientist
Division of Food Science & Postharvest Technology, IARI, New Delhi-12

What is a Particle Film?



- Microscopic layer of mineral particles
- Forms a complete film
- Allows water and CO_2 to pass through it

History of Particle Film Technology

- In nature, many animal species commonly take "dust baths" to rid themselves of insect parasites and prevent attacks from biting insects
- Soil dusts have also been used as insect repellents by primitive people, mammals and birds regularly to ward off insect pests
- In china, diatomaceous earth (diatomite), was applied to plants for pest control as early as 2000 B.C
- Since that time various mineral-based preparations have been used and some of these are still used for special purposes in agricultural pest control

Commercially Available Particle Films in the Global Market

- Surround® (95% Calcined kaolin)
- Surround® WP
- RAYNOX®
- RAYNOX ORGANIC
- Cocoon™ (100% hydrous kaolin)
- Parasol®
- Anti-stress 500®
- Purshade® (62.5 % limestone)
- Screen®
- Snow®

Characteristics of an Ideal Particle Film

- Chemically inert mineral particle
- The particle diameter should be < 2 μm
- Ability to get formulated to spread and create a uniform film
- Should form a porous film that doesn't interfere with the gas exchange
- Transmit photosynthetically active radiation (PAR) but excludes ultraviolet (UV) and infrared (IR) radiation to some extent.
- Alter insect/pathogen behavior on the plant
- Easily removable form the harvested produce

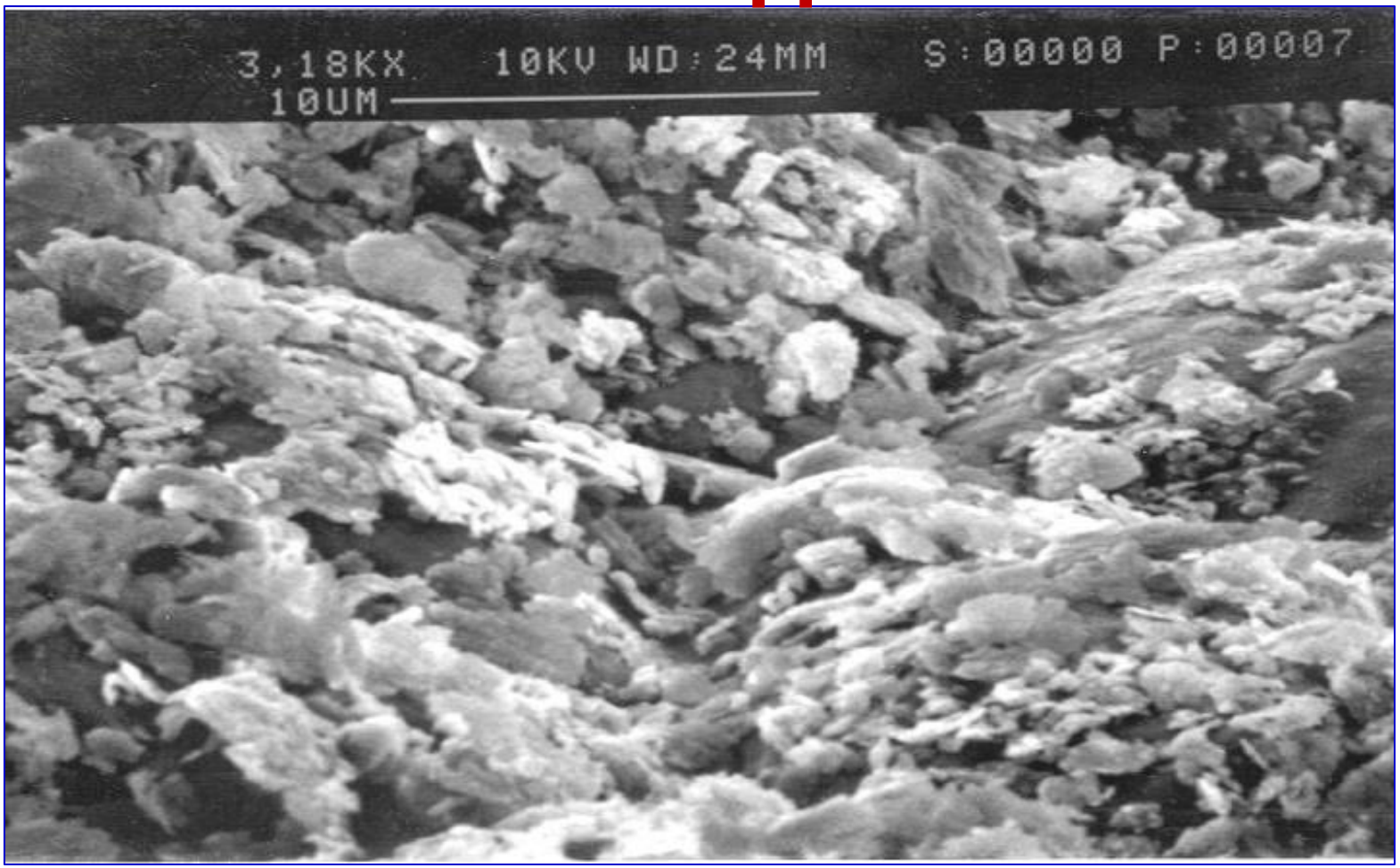
Effects of Particle Films on Fruits

- Reduces sunburn and mitigate heat stress
- Reduce harmful insects
- Reduce fungal and bacterial infections
- Freeze protection
- Reduces fruit cracking
- Improvement in fruit weight, colour and cosmetic appeal
- Improve postharvest life and fruit quality

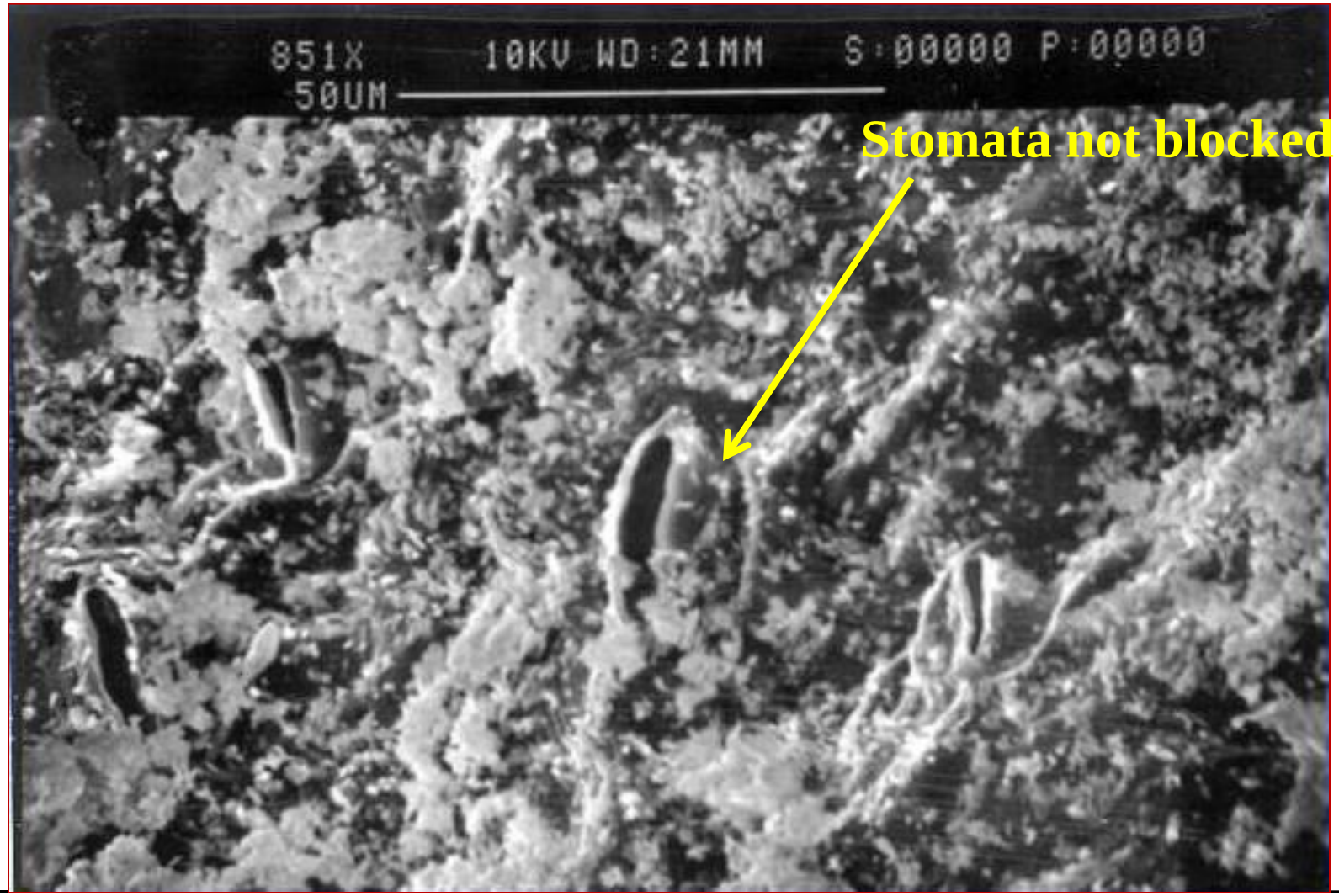
Effects of Particle Films: Insect pests

- Particle films suppresses insect pests in many other ways:
- Repellency
- Impedes egg laying
- Reduces feeding
- Impedes grasping
- Restricts movement
- Induces paralysis
- Causes mortality

Particle film of processed kaolin on upper surface of apple leaf



Particle film of processed kaolin on lower surface of apple leaf



Application of Particle films



Can be done using conventional equipments

First spray

Second spray

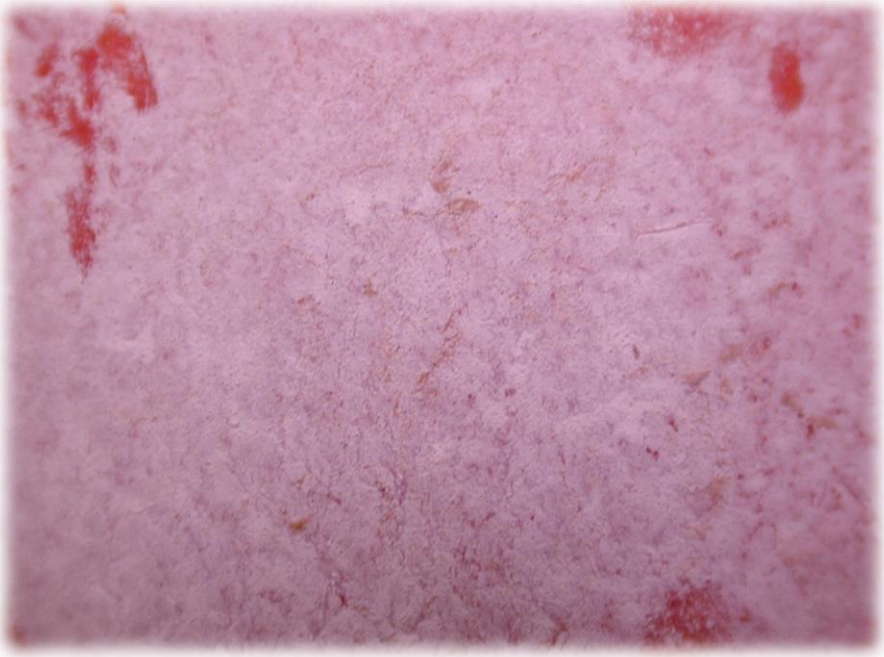
Third spray



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



Uniform coverage is important



Uniform coverage



Non-uniform coverage leaves excessive deposits

Mechanisms that reduce sunburn damage in fruits

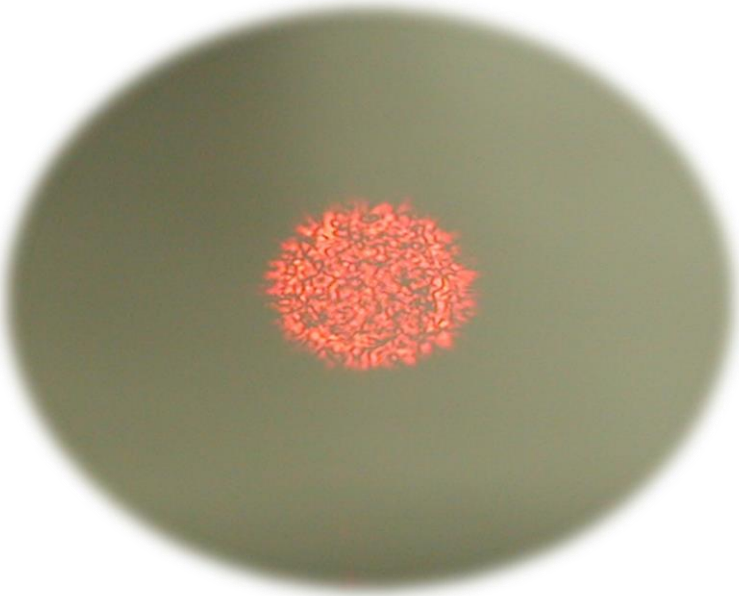
- Reduced temperature
- Reflection of IR
- Reflection of UV



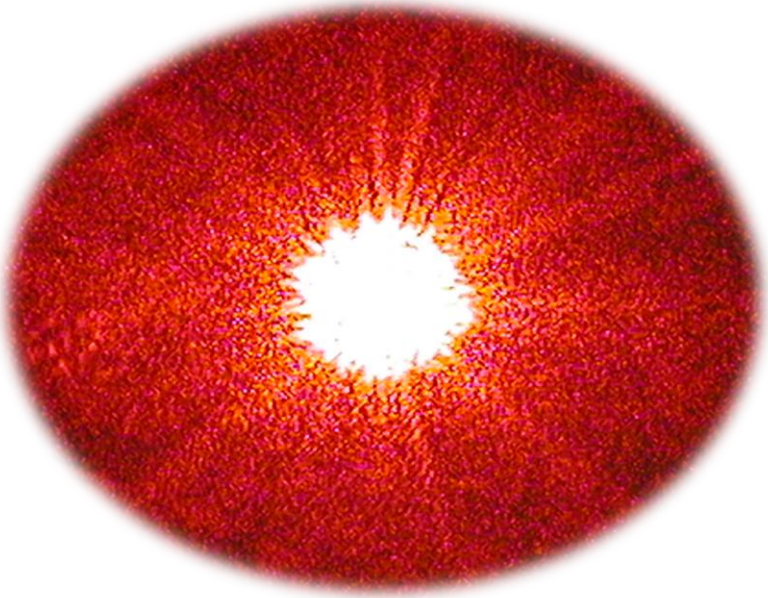
Digital image

Reflective surfaces are common plant adaptation (Pubescence, cuticular waxes) and PFT builds on this strategy

How do particle films alter light transmission and scatter?



Laser on glass

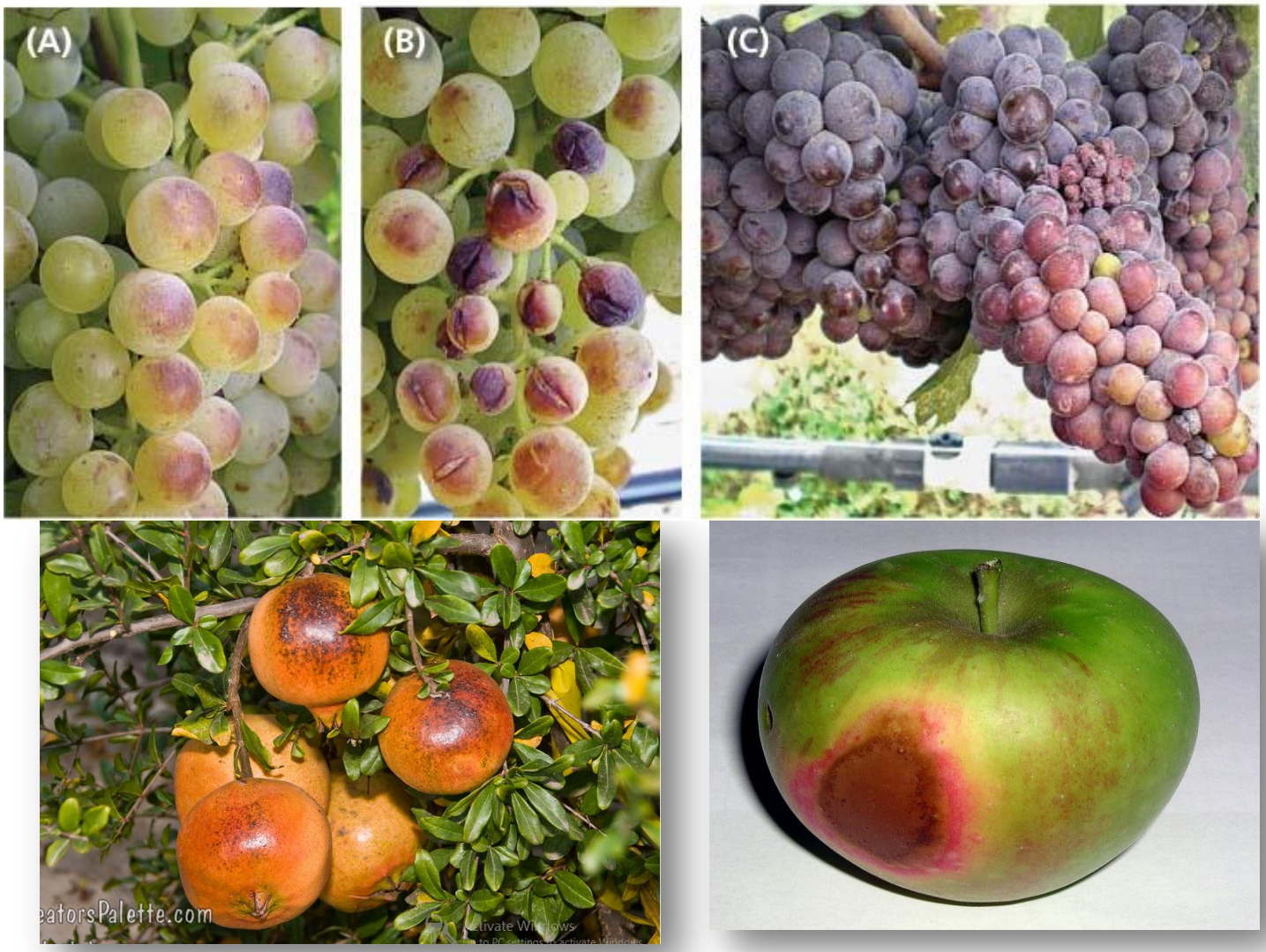


Laser on particle film

A view of Increased light scatter within the plant canopy

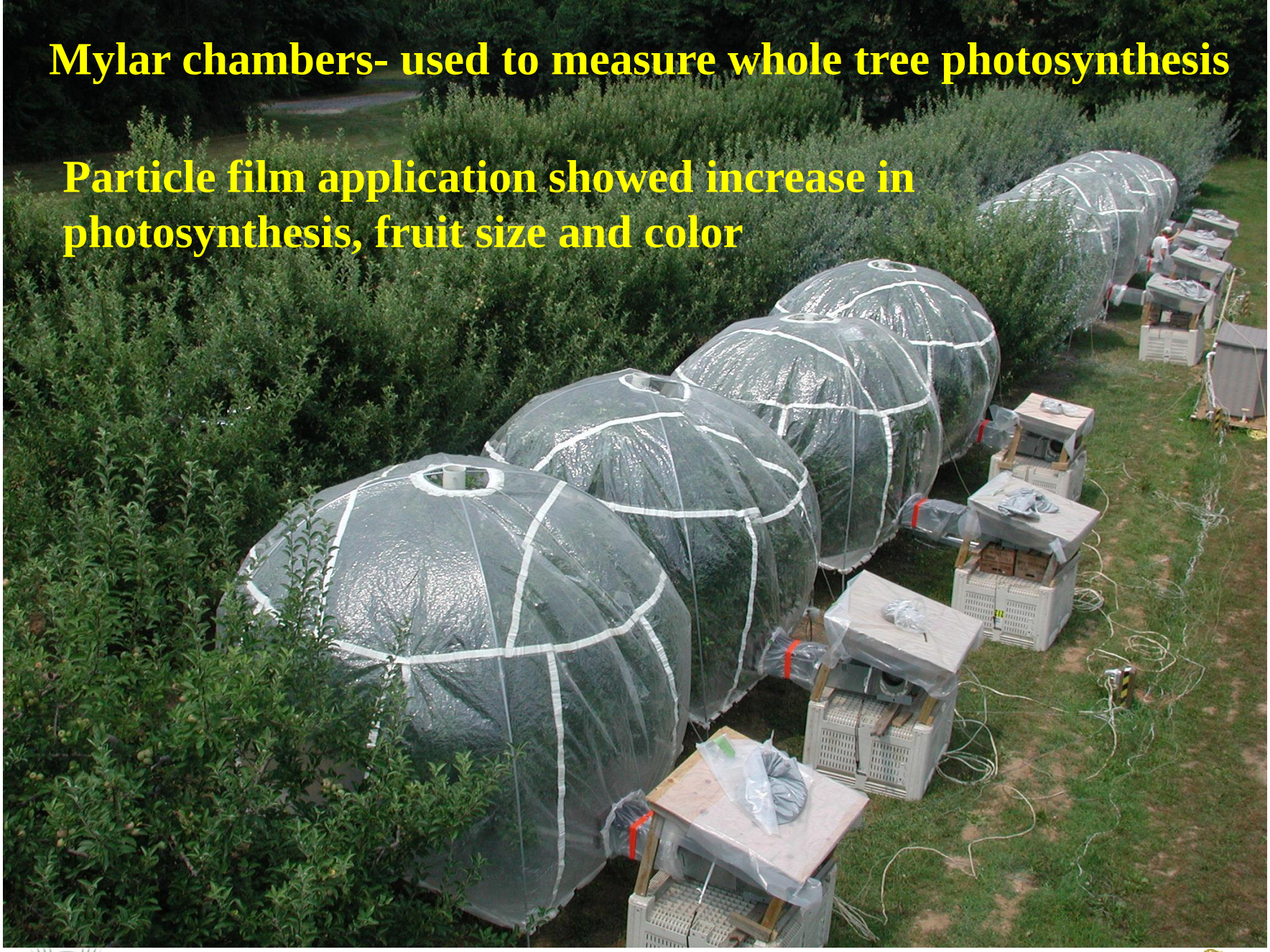


Solar injury/Sun burn in fruits



Mylar chambers- used to measure whole tree photosynthesis

Particle film application showed increase in photosynthesis, fruit size and color



Reduced fruit cracking in 'Stayman' apple by PFs



Untreated had 32 % cracking



Treated had 22 % cracking

A 10 % reduction in cracking results in greater net returns to the grower

Particle Films for Disease Control



Fabraea leaf spot in Pear



The tree in the foreground is defoliated by leaf spot, those in the background are only treated with Surround

Effect of 'Surround' on Fruit Color



Control



Surround 3%



Surround 12%





Studies on the Impact of Particle Films on Royal Delicious apple





Particle Films

- Particle film is a microscopic layer of mineral particles.
- Allows water and carbon dioxide to pass through it.
- Some PFs have been developed but no attempt has yet been made on their use in India or SE Asia.

Particle films

- **Surround (Glenn & Putreka, 2005) was obtained from France.**
- **Raynoux (Schrader, 2011) was obtained from USA.**
- **Three sprays each of Surround (3%) and Raynoux (1%) were given on apple at fortnightly interval, starting from 15th June, 2014 at IARI Regional Research Station, Katrain**

Imported Particle Films





Spraying Apples Trees with Surround and Raynoux



Surround



Raynoux





Royal Delicious Apple with and without Surround



Effect of Particle Films on Royal Delicious Apples

Particle film	Maturity date	Hunter 'a' value	TPC (mg/ 100 ml GAE)	AOX (µM Trolox/ml)	SSC (%)
Surround	17th August	52.4±0.2	112.5±3.6	15.2±1.2	14.6±0.1
Raynoux	12th August	46.3±0.3	110.5±3.8	12.6±1.6	14.0±0.2
Control	8th August	33.2±0.2	99.5±4.2	10.4±1.5	13.2±0.2

Colour Development in PF-treated apples

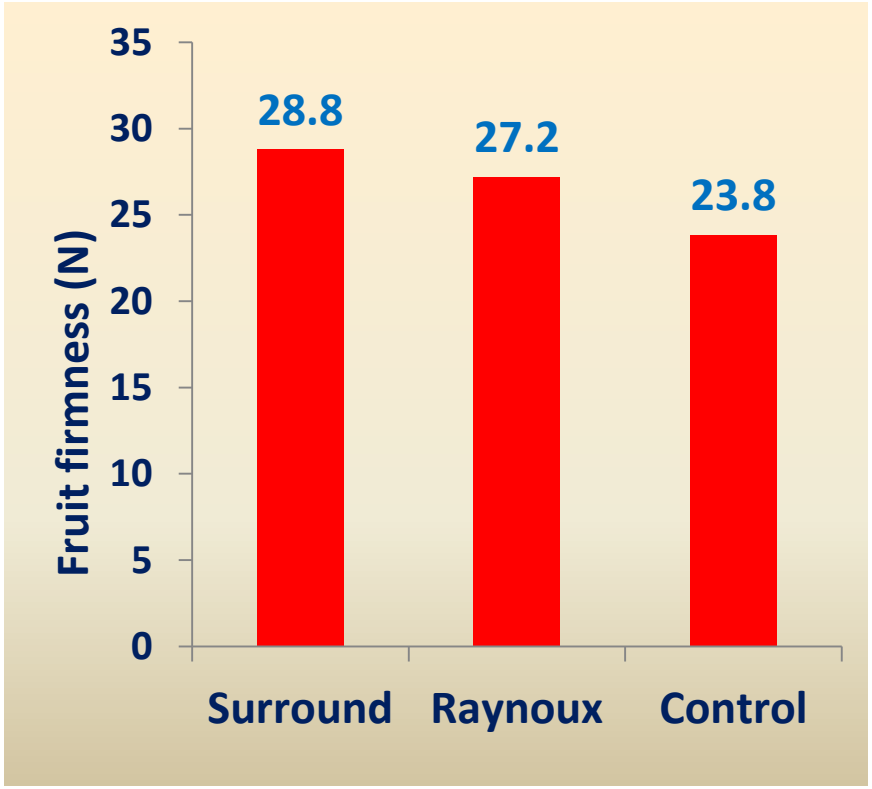


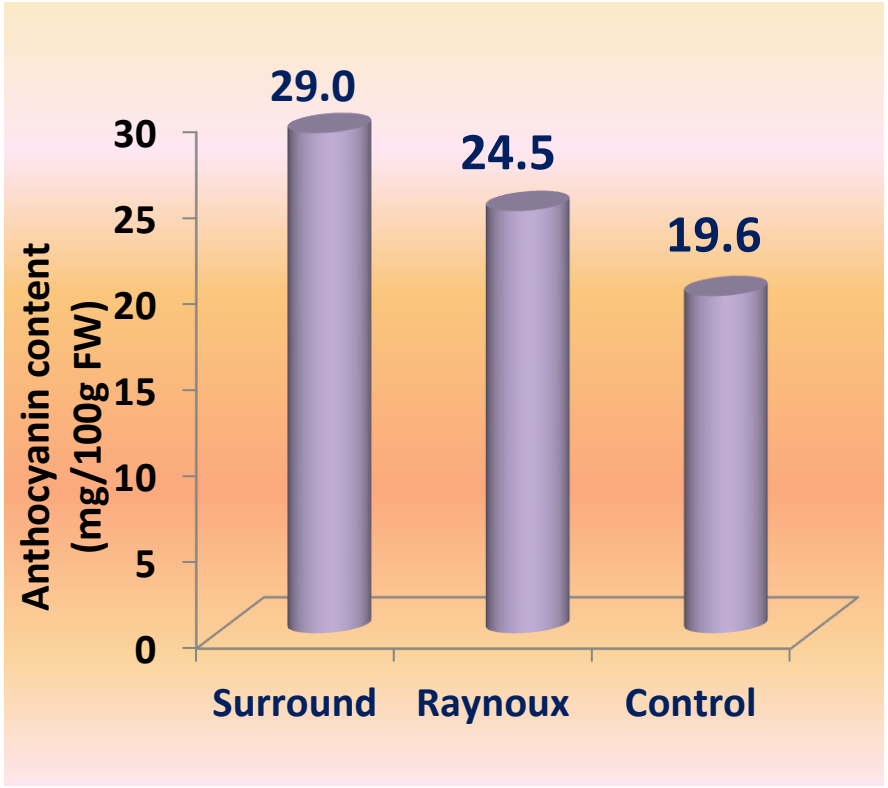




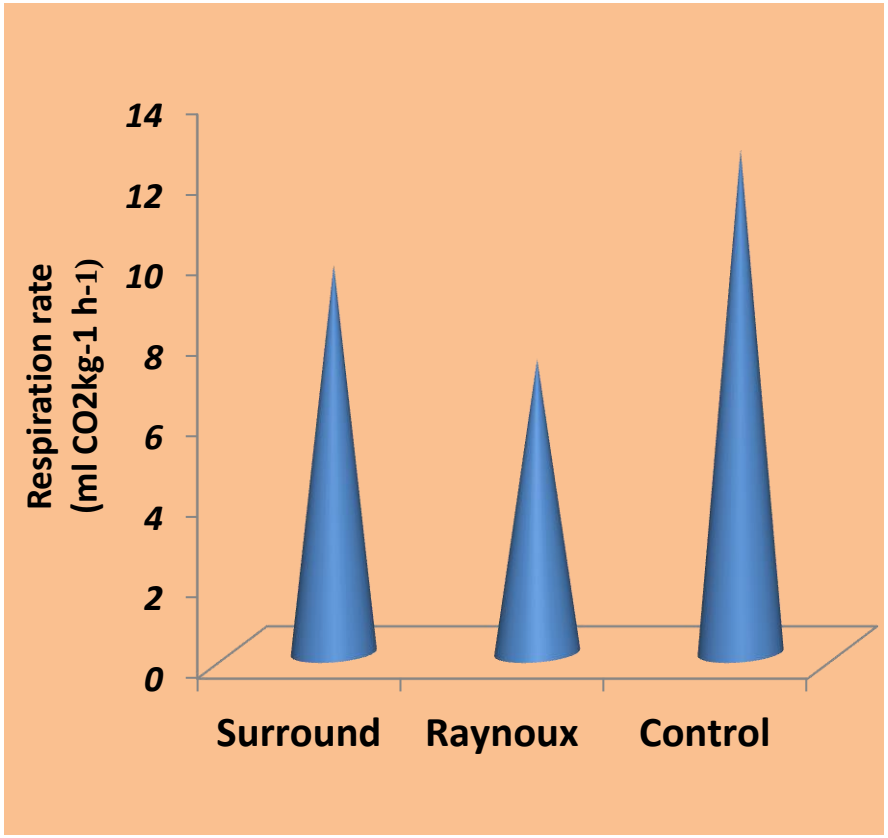


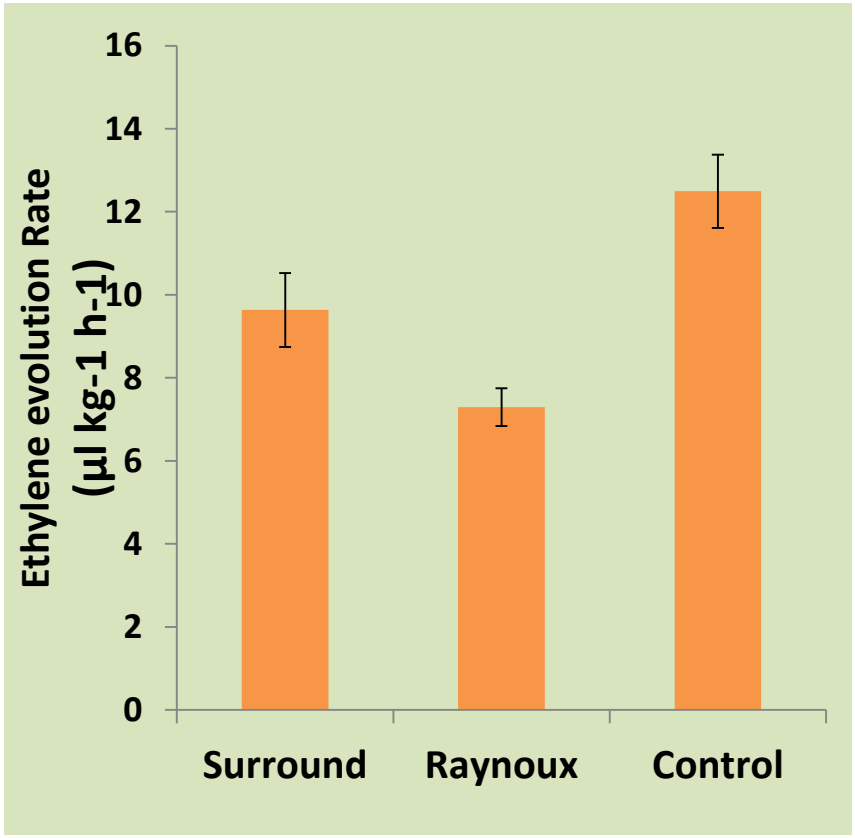
Effect of PFs on Fruit Firmness & Anthocyanin Content of Royal Delicious apple





Respiration and Ethylene Evolution Rates of PF-treated vs. Non-treated apples





Major Biotic Factors Responsible for Causing Losses in Apples



Woolly aphid



Scab



Sanjos Scale







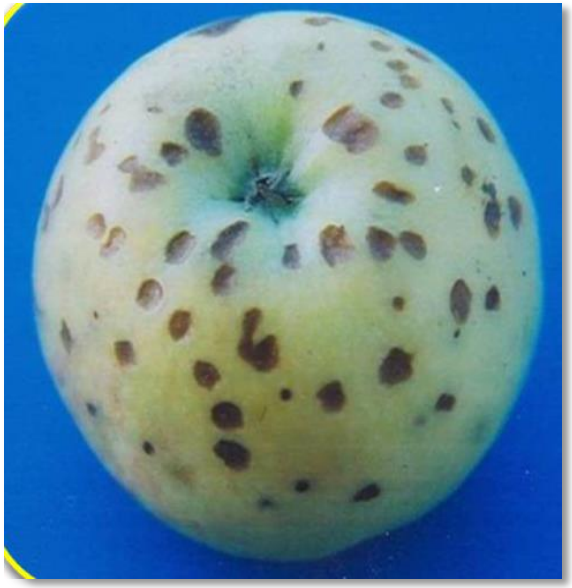
Influence of Particle Films on Insect-Pests and Diseases in Apple

Particle film	San Jose scale	Woolly apple aphid	Apple scab
Surround	2.8±0.4%	8.6±0.2%	2.2±0.4%
Raynoux	2.1 ±0.4%	2.6±0.3%	2.8±0.3%
Control	29.4 ±0.3%	7.8±0.2%	16.4±0.6%

Effect of Particle Films on Shelf-life, PAL and LOX activity in Royal Delicious apple

Treatment	Shelf-life (days)	PAL Activity (µM CA/min/g FW)	LOX activity (▲OD/min/g FW)
Surround-treated	28	0.698	0.421
Raynoux-treated	38	0.712	0.324
Control	21	0.495	0.586

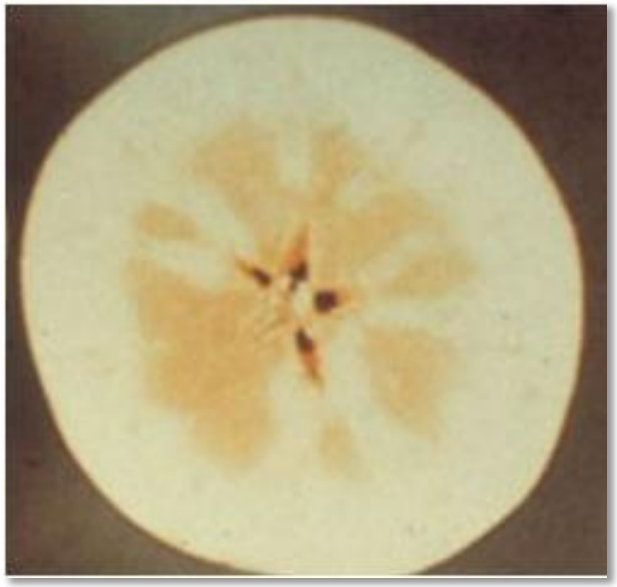
Major Postharvest Disorders of Apple



Bitter pit



Moldy core



Water core

Storage Disorders in PF-treated *vs* Non-treated Apple (at the end of 6th month)

Particle film	Incidence of Postharvest disorders (%)		
	Bitter pit	Moldy core	Water core
Surround	1.8±0.05%	2.3±0.3%	4.1±0.4%
Raynoux	1.2±0.05%	1.2±0.2%	2.2±0.2%
Control	16.2 ±0.4%	8.8±0.2%	11.2±0.3%


Than ‘Q’