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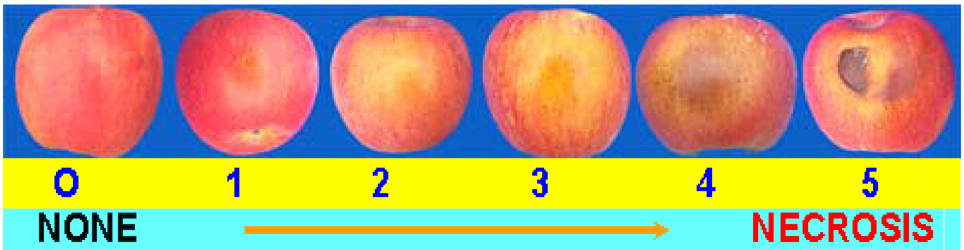
Fruit surface disorders

The final eating quality of fruit is mostly determined by internal parameters such as accumulated sugars, acids, fruit firmness and volatile aroma compounds. However, grade standards within apple packing houses are mainly focused on appearance. Hence it is important for growers to not only produce physiologically sound fruit that can withstand the stresses of long term storage and transport, but to produce fruit of acceptable size, colour and free of any skin defects. Fruit surface blemishes cost the Washington industry millions of dollars every year. The two most common maladies are sunburn and russet.

Sunburn

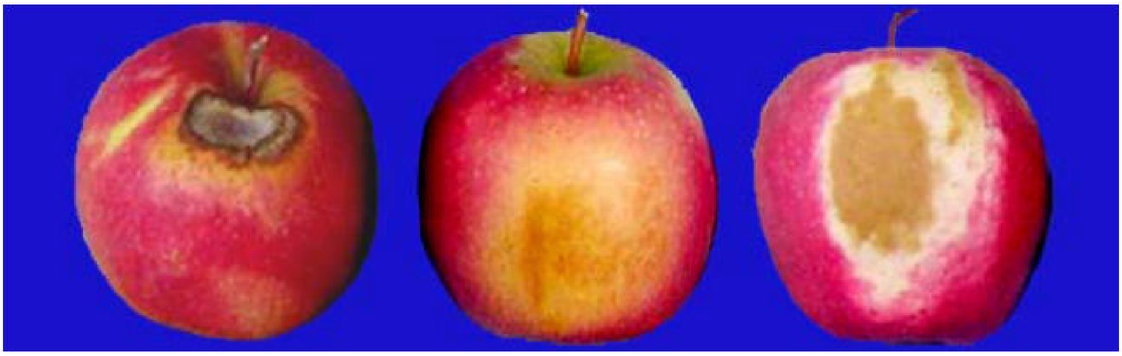
Sunburn is the primary physiological reason for cullage and without protection, 50% of the fruit in a given orchard can be affected. WTFRC has a long cooperation record with Dr. Larry Schrader's lab. One of the outcomes is the development of a rating scale (Picture1).

Picture 1: Six classes of sunburn: The Schrader and McFerson system



Larry Schrader has established that three types of sunburn are caused by heat and/or light stress (Picture 2). Sunburn necrosis occurs when the fruit surface temperature (FST) reaches 126 ºF for only 10 minutes. At this FST, thermal death occurs on the skin. The most prevalent type of sunburn (sunburn browning) is induced when the FST reaches 114 to 120 ºF for 1 hour. Apple varieties differ in their tolerance to temperature stress (i.e., some sunburn at a lower FST than others). Damaging ultraviolet-B (UV-B) radiation also contributes to sunburn browning. The third type of sunburn (Type 3) occurs on "non-acclimated" apples that are suddenly exposed to full sunlight (e.g., after thinning or shifting of a branch as fruit load increases). Type 3 sunburn can occur at much lower air and fruit surface temperatures, and does not appear to require UV-B. Initial damage is seen within 24 hours as bleaching or whitening of the sun-exposed apple skin surface. With continued exposure to sunlight, the bleached area turns brown.

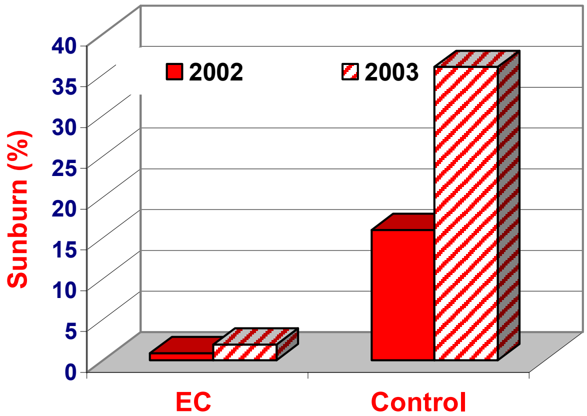
Picture 2: Three types of sunburn in apple.



Left to right: Sunburn necrosis, sunburn browning, and Type 3 sunburn.

The most common methods to suppress sunburn are evaporative cooling and the application of sunburn protectants used alone or in combination. Evaporative cooling can be initiated manually, or automatically with new technology that track fruit surface temperatures. With the help of a fruit surface temperature sensor (FST) sunburn levels can be reduced to below 3% (Figure 1).

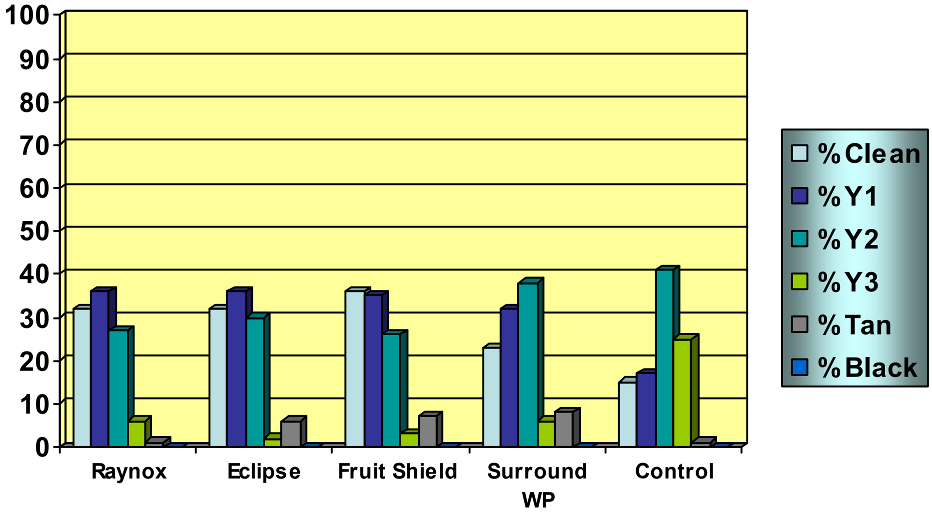
Figure 1: Effect of EC on 'Fuji' sunburn in 2002 and 2003 (TFREC, Wenatchee).



FST controlled evaporative cooling also potentially conserves water and electricity compared to standard hydrocooling systems.

Several spray materials are effective in suppressing sunburn as well. Surround® WP (highly refined kaolin clay) and Raynox ™ (lipophilic matrix) are industry standards for sprayable sunburn protection. These materials can reduce sunburn-related cullage by approximately 50%. In 2005, we tested some calcium-based materials as well (Eclipse, Fruit Shield). Overall, we are encouraged by good performances from newer calcium-based products, which have potential to increase market competition for Surround ®WP and Raynox ™ and drive down prices for all materials (Figure 2).

Figure 2: Sunburn ratings for Golden Delicious apples (2005)



Unfortunately, we have yet to observe an increase in fruit calcium levels from treatment with Fruit Shield (Genesis Ag) or Eclipse (D & M Chemical). One common concern within the industry is the ability to remove particle films from the surface of fruit in the packing process. In a recent WTFRC trial, fruit treated with sunburn protectants were run across a research packing line with a standard wet dump tank and brush bed. No material residue was observed at the end of the line except Surround®, which was still slightly visible in the stem bowl and calyx ends of fruit.

Fruit russet

Fruit russet is typically induced early in the growing season and is likely aggravated by a combination of weather conditions, spray chemicals, and/or biotic pests on the surface. Washington typically has fewer problems with severe russet than other apple production regions, since springs are mostly dry. However, the 2006 season featured extensive russet pressure, mainly caused by a wet, cool period in early spring followed by extreme heat. Few practical options are available to orchardists to suppress russet. The internal program of WTFRC has experimented with various rates, combinations of, and spray regimes of

ProVide (GA_{4+7}), Novagib (GA_4), Falgro 20 SP (GA_3), FAL 900 (GA_7), Apogee (prohexadione-Ca), and Raynox to reduce russet symptom expression. Results from 2005 trials confirmed the efficacy of gibberellin products (ProVide and Novagib) at various rates and spray regimes for improving fruit finish (Table 1).

Table 1: Fruit finish effects of commercial gibberellin formulations on Pacific Rose apples (2005)

Treatment	Russeted fruit	RUSSET TYPE		
		Stem bowl	Shoulder	Flank netting*
	%	%	%	%
Novagib 15ppm 4x	36 ab	8 ns	23 ab	6
Novagib 20ppm 4x	36 ab	0	28 a	8
Novagib 26ppm 3x	21 b	6	6 b	8
Novagib 26ppm 4x	19 b	8	8 b	4
ProVide 15ppm 4x	24 ab	3	18 ab	4
ProVide 19ppm 4x	20 b	8	10 ab	3
ProVide 25ppm 3x	25 ab	8	15 ab	3
ProVide 25ppm 4x	35 ab	14	18 ab	4
Control	50 a	9	28 a	14

* values pooled from ratings of 5%, 10%, and 25% net-type russeting on flanks of fruit

Treatments generally reduced russet on fruit shoulders and flanks. Gibberellins are known to be inhibitors of floral initiation in apple, especially materials containing GA_7, such as ProVide. All treatments generally reduced return bloom, with higher GA rates being most inhibitory. (Table 2).

Table 2: 2006 return bloom of Pacific Rose apples treated with gibberellins in 2005

Treatment	Return bloom
	per CSA
Novagib 15ppm 4x	0.96 b
Novagib 20ppm 4x	2.21ab
Novagib 26ppm 3x	1.24ab
Novagib 26ppm 4x	2.97 a
ProVide 15ppm 4x	2.41ab
ProVide 19ppm 4x	2.41ab
ProVide 25ppm 3x	2.43ab
ProVide 25ppm 4x	0.73 b
Control	1.49ab

In 2006, we tested additional GA products and narrowed down optimal timings and concentration. Furthermore we designed some of our 2006 chemical thinning trials to study fruit finish effects of drying conditions, sprayer technology and carrier volume. These results will be discussed in the oral presentation, since trial harvest and analysis are still on-going.

Fuji flecking is a ‘russet-like’ disorder (Picture 3). The causes of this skin disorder are not well established yet. It is thought that the disorder is induced during rapid expansion of the fruit during its first few weeks of development. Schrader’s group has established that the severity of this disorder is enhanced by conditions that cause high relative humidity around the fruit. These conditions include overhead irrigation that keeps the fruit wet for long periods of time. Evaporative cooling can also enhance appearance of flecking. Apples in trees with dense canopies are more prone to developing flecking than those in open canopies.

Picture 3: Fuji flecking

Our recently upgraded website includes a searchable database of all WTFRC-funded projects for the last several years. Please visit www.treefruitresearch.com