Research Reports

The Influence of Reflective Film and ReTain on Red Skin Coloration and Maturity of 'Gala' Apples

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Summary. **Replicated trials were conducted in Summers 1998 and 1999 at two commercial orchards (A and B) to determine the influence of a metalized, high density polyethylene reflective film (SonocoRF) and aminoethoxyvinylglycine (ReTain), on fruit red skin coloration and maturity of 'Gala' apples (*Malus sylvestris* var. *domestica*). There were four experimental treatments: 1) nontreated control; 2) reflective film (RF); 3) ReTain; and 4) RF + ReTain. RF was applied 4 weeks before anticipated start of harvest by laying a 5-ft-wide (150-cm) strip on each side of the tree row in the row middle. ReTain was applied 4 weeks before harvest at the commercial rate in one orchard and at 60% of the commercial rate in a second test. ReTain delayed fruit maturity. Fruit from RF trees had a significantly greater percent surface red color than fruit from trees not treated with RF. Fruit from RF + ReTain were significantly redder and had higher soluble solids concentration (SSC) than fruit from trees treated with ReTain alone. There were no differences in size, fruit firmness or starch content between fruit from RF and RF + Retain. RF appears to be a method to increase red skin coloration in 'Gala' apples treated with ReTain without adversely impacting maturity.**

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One of the primary determinants of the value of many apple cultivars is fruit red color. Red skin coloration of apples is directly related to the proportion of red-pigmented cells in the epidermis (skin) and the size of the vacuoles containing the anthocyanin pigments (Lancaster et al., 1994). The maximum capability for anthocyanin synthesis is genetically controlled, so cultivar choice will determine maximum red color potential (Mancinelli, 1985). Environmental factors interact with the genetic factors to determine final red color. Anthocyanin synthesis in apple fruit skin is both light [visible and ultraviolet (UV)] (Dong et al., 1995) and temperature-dependent (Saure, 1990). Depending on whether a particular variety is grown in Washington or Ohio, for example, the average growing season irradiance may be different and have a significant impact on yield and skin color (Doud and Ferree, 1980a). 'Gala' grown in South Carolina often does not develop sufficient red color in comparison with 'Gala' grown in Washington or New Zealand, for example (Layne, personal observation).

Horticultural practices can impact fruit appearance and quality at harvest. Proctor and Lougheed (1976) noted that a strong relationship existed between red coloration and exposure of fruit to sunlight near harvest for 'McIntosh' apple. Reflective films or mulches have been used to reflect sunlight from the orchard floor into the canopy. Reflective mulches have resulted in substantial improvements in red skin coloration and a slight increase in maturity of peach (*Prunus persica*) (Layne et al., 2001). Several studies have been reported over the last 25 years using this solar reflection concept in apple (Andris and Crisosto, 1996; Doud and Ferree 1980a; Moreshet et al., 1975; Toye, 1995). Today, reflective mulches are used in tree fruit and grape (*Vitis vinifera*) production in many countries around the world (K. Williamson, personal communication). These mulches reflect solar radiation into the tree canopy and may increase canopy absorption of photosynthetic photon flux (*PPF*) by up to 40% (Green et al., 1995). This additional light is useful for both photosynthesis and anthocyanin pigment production.

'Gala' apple is grown in South Carolina because it is an early season, fresh-market cultivar that has the potential to be highly profitable. However, in this hot, summer climate, 'Gala' has a tendency not to develop good red color. A second problem is that fruit tend to drop prematurely. The plant growth regulator, aminoethoxyvinylglycine (AVG) inhibits ethylene biosynthesis (Yu and Yang, 1979), delays ripening and reduces preharvest drop in apples (Bangerth, 1978). AVG is now commercially available (ReTain; Valent Biosciences, Libertyville, Ill.) as a harvest management tool (Shafer et al., 1997). One disadvantage of using ReTain in the 'Gala' cultivar, is that treated fruit may not develop the

Table 1. Research trial specifications at each commercial apple orchard (Orchard A is in Gray Court, S.C., and Orchard B is in Monetta, S.C.) used in South Carolina during 1998 and 1999. Rootstock M.7A[z] was used for both cultivars.

Orchard	Cultivar	Tree age (years)	Density (trees/acre)[y]	Plot size (no. of trees)	Row orientation[x]	Training system	Film application date	ReTain application date[w]	First harvest date
1998									
A	'Imperial Gala'	3	550	13	N–S	Modified central leader on trellis	5 July	6 July	5 Aug.
1999									
A	'Imperial Gala'	4	550	13	N–S	Modified central leader on trellis	18 July	19 July	18 Aug.
B	'Gala'	7	218	200	NE–SW	Modified central leader	12 July	13 July	12 Aug.

[z]M.7A corresponds to a semidwarfing apple rootstock developed at the East Malling Research Station in Kent, England.
[y]1 tree/acre = 2.5 trees/ha.
[x]N, S, NE, and SW correspond to compass directions north, south, northeast, and southwest, respectively.
[w]At Orchard A in Gray Court, S.C., ReTain was applied at 60% of the commercially recommended label rate both in 1998 and 1999. At Orchard B in Monetta, S.C., ReTain was applied at the full commercially recommended label rate.

same degree of red skin coloration as nontreated fruit (Byers, 1997).

This study was initiated to evaluate the effect of RF alone or in combination with ReTain on red skin color of 'Gala' apples grown in South Carolina. Three objectives were established: 1) to determine if RF alone would increase red skin color, 2) to quantify the effect of a RF on red skin color of apples treated with ReTain, and 3) to examine the interaction of RF and ReTain on the maturity of 'Gala' apples. Studies were conducted in commercial orchards over 2 years to confirm findings.

Materials and Methods

Field plot design. Trials were carried out on two grower farms ranging from 5 to 20 acres (2.3 to 9.1 ha) in size. Specific details concerning the trials and respective orchards are presented in Table 1. A randomized complete block experimental design was used for each trial with four experimental blocks. For high density trees at Orchard A, Gray Court, S.C., individual treatments comprised 13 adjacent trees down the row. RF blocks were separated down the tree row by at least two trees and they were separated from each other by at least one row of trees on either side. For low density trees at Orchard B, Monetta, S.C., individual test blocks were larger and comprised 200 trees each (8 rows wide by 25 trees long). In both trials, experimental blocks were oriented such that two individual RF treatments were not adjacent to each other. The outer trees (or rows) of each block were used as buffers against edge effects and fruit sampling was confined to the inner trees (or rows) of a respective treatment. The orchards were maintained according to the grower's standard practices for weed, insect and disease control and crop load management (North Carolina Cooperative Extension Service, 2000).

RF laying. RF was applied 4 weeks before the first anticipated commercial harvest date. The RF was a high density polyethylene material (Sonoco RF; Sonoco Products Co., Hartsville, S.C.) with a highly reflective metalized surface resembling aluminum foil and supplied in rolls 5 ft (150 cm) wide and 4000 ft (1219 m) long. On the day before RF application, the orchard sod middle was mowed short [2 inches (5 cm)] by the grower and the RF rolled out by hand such that it was located in the drive middle between the tree rows. The RF was secured to the ground with soil every 6 ft (2 m) on either outside edge. At row ends, the entire end of the plastic was covered with soil and secured to the orchard floor. The RF was maintained on the orchard floor throughout the entire harvest period and in some cases was not taken up until the fall.

ReTain application. In Orchard A during 1998, ReTain was applied at (a.i.) 7 oz/acre (494 g·ha^{-1}) 4 weeks before the anticipated first harvest date (Table 1). ReTain was applied by airblast sprayer, calibrated to apply 100 gal/acre (936 L·ha^{-1}) with 0.05% (vol/vol) Silwet L-77 organosilicone surfactant (Crompton Corp., Greenwich, Conn.). In 1999 at Orchard A, there were four treatment plots that were not sprayed with ReTain. Otherwise, the entire orchard received the same timing, rate, and method of application of ReTain as in 1998. This was a split-plot design with ReTain. The same trees were used in Orchard A for trials in both years. In the 1999 'Gala' trial at Orchard B, only half of the orchard was sprayed with ReTain. Application was by airblast sprayer as noted above 4 weeks before anticipated first harvest date. In Orchard B, however, the full label recommended rate (a.i.) of 11.7 oz/acre (818 g·ha^{-1}) was used.

Light quality and quantity determination. Light quality was determined using a portable spectroradiometer (LI-1800; LI-COR, Inc., Lincoln, Nebr.) that was programmed to record data at 10-nm increments from 330 to 1100 nm. Two light quality parameters were calculated based on spectral distribution data, namely phytochrome photoequilibrium and red-to-far red ratio measured at 10 nm increments ($R/FR_{10\,nm}$) (Cerny et al., 2000; Sager et al., 1988). The spectroradiometric data from 330 to 400 nm comprised UV-A light, however, UV-B (280 to 320 nm) and UV-C (100 to 280 nm) were not measured. Light quantity was determined as *PPF* using a line quantum sensor (LI-190SA) attached to a datalogger (LI-1000). All light measurements were taken on 21 Aug. 1998 at Orchard A. One week following completion of harvest, light sensors were held 3 ft (1 m) above the ground either facing the sun (sky) or ground (reflection) directly and data were collected between 1258 and 1355 HR under clear sky conditions. Light readings over RF were in the middle of the RF strip directly over the center of the plastic. Light reflectance data were also collected in the tree canopy (as noted in Table 3). For these measurements, light sensors were set at 3 ft height halfway into the tree canopy to the main leader and were pointed at the herbicide strip below. Readings were

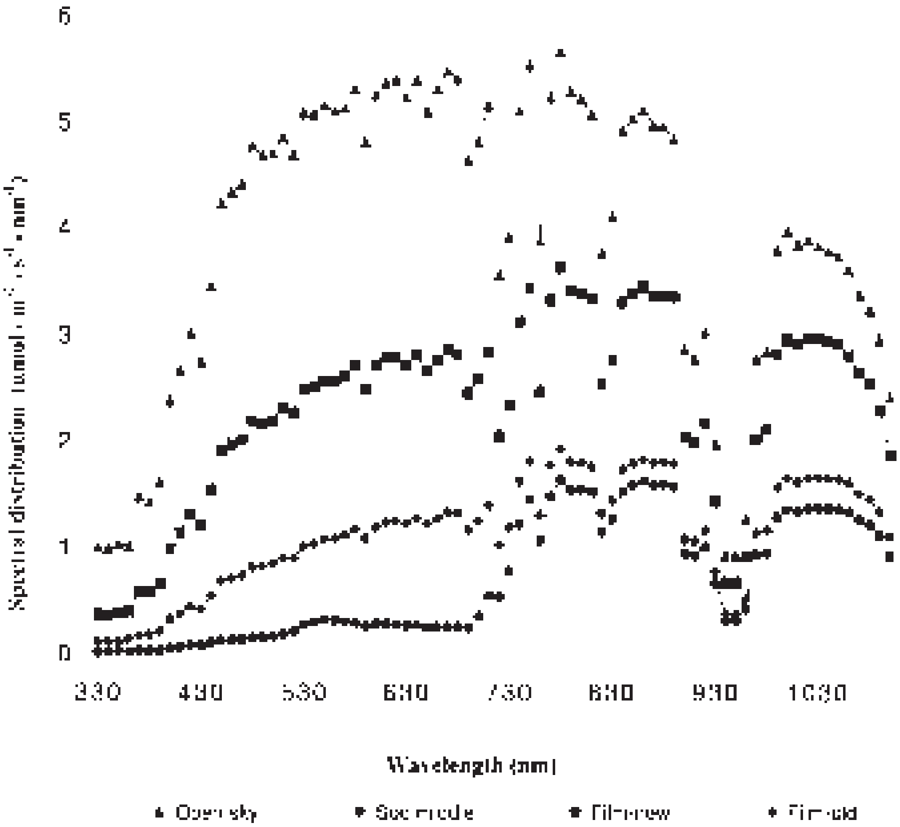

Fig. 1. Spectral distribution curves for incident (open sky) and reflected light (sod middle, new and old film) in the 'Imperial Gala' apple Orchard A, Gray Court, S.C., from 1258 to 1355 HR on 21 Aug. 1998. Each point represents the mean of measurements from four blocks. Open sky corresponds to readings taken outside the orchard where there were no trees directly overhead. Sod and film correspond to reflection readings taken in the drive middle of the orchard with the sensors facing downwards over sod and film, respectively. Old film had remained on the orchard floor for 6 weeks. New film was applied immediately before data collection. All readings were taken at 3 ft (1 m) height above the ground.

also taken at the same position for the RF treatment where sensors were adjusted to a 45° angle from vertical to intercept reflected light coming from the RF in the orchard row middle.

FRUIT HARVEST. Generally, fruit samples were harvested in the early morning of the day that the grower began his first major harvest for that cultivar. A reference sample based on size was selected at the beginning of each harvest date that represented the minimum stage of maturity for test sampling. This reference was used for all fruit collected on that date. Fruit were only harvested from healthy, uniform-sized trees within the orchard. For each trial, both the RF and control treatments were harvested on the same day. In 1998 and 1999, a 50-fruit sample was hand-harvested randomly from trees in each treatment per block. Fruit were randomly selected from those in a mid canopy zone, 3 to 7 ft (1 to 2.1 m) above the soil surface and to a minimum size of 2.5 inches (64 mm) diameter. Fruit were evaluated the day of harvest.

FRUIT COLOR AND MATURITY EVALUATION. Fruit were sorted into one of four visual color ratings: 0% to 25%, 26% to 50%, 51% to 75%, and 76% to 100% red surface. Fruit were not evaluated for ground color. The number of fruit in each color rating category was counted for each sample. Immediately following color sorting, a 10-fruit subsample was selected for evaluation of maturity and fruit quality. This subsample was a proportional representation of the 50-fruit sample based on the color categories represented.

Fruit diameter (inches) was measured using a digital caliper (Mitutoyo Corp., Kanagawa, Japan) for each fruit at the widest point along the stem-blossom end axis of the fruit in two perpendicular directions. An average of these two measurements was calculated and used for statistical analysis. Fruit firmness was measured after a 2-cm (0.8-inch) disk of skin was removed mid-cheek on opposite sides of the fruit using a penetrometer (Effigi model FT327; McCormick Fruit Tech., Yakima, Wash.) equipped with an 11-mm (0.4-inch) tip. SSC was determined on a fresh squeezed juice sample from each fruit using a calibrated temperature compensating refractometer (model N-20E; Atago Co., Ltd., Tokyo). Flesh starch content was evaluated by iodine staining (Poapst et al., 1959; Smith et al., 1979). The degree of staining was rated on a visual scale of 1 to 6, where 1 = staining the entire cut surface and 6 = no staining.

DATA ANALYSIS. All data were subject to analysis of variance using SAS version 6.12 software (SAS Institute Inc., Cary, N.C.).

Results

LIGHT QUALITY AND QUANTITY. Incident sunlight had greater light intensity at all measured wavelengths than light reflected from the RF or the sod (Fig. 1). The spectral distribution of the reflected light from the RF was similar to that of incident sunlight, while reflected light from the sod had a very different spectral distribution. In particular, most wavelengths of light from 330 to 730 nm were absorbed by the sod and not reflected. *PPF* was also significantly greater for direct sunlight than sunlight reflected from the RF or the sod (Table 2). This proportional reduction in intensity of reflected light from RF versus incident sunlight was uniform across the wavelengths measured (Fig. 1). Based on phytochrome photoequilibrium and $R/FR_{10\ nm}$ parameters that were calculated, reflected sunlight from the RF was not different in quality from that of incident sunlight (Table 2). On the other hand, reflected sunlight from the sod had a lower phytochrome photoequilibrium and lower $R/FR_{10\ nm}$. Most of the incident *PPF* (400 to 700 nm) was absorbed by the sod foliage and not reflected. RF that had remained on the orchard floor for 6 weeks before taking light readings was significantly less reflective than new RF. Old RF became dirty from dust, spray and other deposits which reduced its reflective properties. Reflected light quality in the drive row middle and in the canopy

Table 2. Quality and quantity of incident sunlight compared with that reflected from the sod middle, new, and old reflective film, respectively, in an 'Imperial Gala' apple orchard.[z]

Light reading position	Sample size (n)	Phytochrome photoequilibrium[y]	$R/FR_{10\ nm}$[x]	*PPF*[w] ($\mu mol \cdot m^{-2} \cdot s^{-1}$)
Open sky	4	0.72 a[v]	1.19 a	1518 a
Sod middle	4	0.52 b	0.29 c	69 d
Film, new	4	0.71 a	1.02 a	685 b
Film, old	4	0.69 a	0.91 b	280 c
$LSD_{0.05}$	---	0.10	0.19	54.9

[z]Data were collected on 21 Aug. 1998 at Orchard A in Gray Court, S.C., from 1258 to 1355 HR on a clear, sunny day.
[y]Phytochrome photoequilibrium was calculated according to Sager et al. (1988).
[x]R/FR_{10nm} corresponds to the ratio of photon flux density values of red (660 nm) to far red (730 nm) measured at 10 nm bandwidth by spectroradiometry.
[w]*PPF* corresponds to photosynethetic photon flux over the 400 to 700 nm range determined by ceptometry.
[v]Means within columns with different letters are significantly different at $P = 0.05$.

Table 3. Reflected sunlight quality and quantity in the drive row middle and in the canopy in 'Imperial Gala' apple Orchard A, Gray Court, S.C.[z]

Treatment and position	Sample size (n)	Phytochrome photoequilibrium[y]	$R/FR_{10\ nm}$[x]	*PPF*[w] ($\mu mol \cdot m^{-2} \cdot s^{-1}$)
Control				
Drive row middle	4	0.51 c[v]	0.32 c	72 bc
Control				
Canopy	4	0.41 d	0.17 d	40 c
Film				
Drive row middle	4	0.69 a	0.92 a	292 a
Film				
Canopy at 45° angle	4	0.61 b	0.50 b	93 b
Film				
Canopy	4	0.55 bc	0.36 c	55 bc
$LSD_{0.05}$	---	0.08	0.13	49.9

[z]Data were collected on 21 Aug. 1998 at Orchard A, Gray Court, S.C., from 1258 R to 1355 HR on a clear, sunny day.
[y]Phytochrome photoequilibrium was calculated according to Sager et al. (1988).
[x]R/FR_{10nm} corresponds to the ratio of photon flux density values of red (660 nm) to far red (730 nm) measured at 10 nm bandwidth by spectroradiometry.
[w]*PPF* corresponds to photosynethetically active radiation over the 400 to 700 nm range determined by ceptometry.
[v]Means within columns with different letters are significantly different at $P = 0.05$.

was different where RF was present than when it was absent (Table 3). Reflected *PPF* was greatest over the RF and least within the canopy above the herbicide strip for the control treatment. A similar trend was noted for the light quality parameters measured. More light was reflected into the canopy from the RF than from the herbicide strip.

FRUIT SIZE, COLOR, AND MATURITY. Fruit size was not affected by RF, ReTain or the combination thereof in any trial in 1998 or 1999 (Tables 4 and 5). In 1998, the use of RF resulted in a 27% increase in percent red surface of 'Imperial Gala' apples compared with the no-RF control where all trees had been treated with ReTain (Table 4). In the same orchard in 1999, the most red color was on fruit from trees treated with ReTain and RF. Trees treated with ReTain only had fruit with the poorest red coloration. Thus, for trees treated with ReTain, the addition of RF resulted in a 38% increase in red surface color. Fruit on trees not treated with ReTain or RF had intermediate red coloration. In the large-scale trial at Orchard B in 1999, there was a significant enhancement in red surface coloration of fruit when RF was used (Table 5). For trees not treated with ReTain, the addition of RF resulted in a 46% increase in red surface coloration. For trees treated with ReTain, the addition of RF resulted in a 56% increase in red surface coloration. Fruit from trees treated with ReTain in 1999 were firmer than fruit from trees not treated with ReTain in both trials. There were no differences in SSC and starch pattern index for ReTain treated fruit in comparison with fruit not treated with ReTain in the 1999 trial at Orchard A. However, at this site, ReTain was applied at only 60% the recommended rate. In the 1999 trial at Orchard B where ReTain was applied at the full commercial recommended rate, there were differences in SSC and starch pattern index. Trees treated with ReTain only had among the lowest SSC while those treated with Film + ReTain had among the highest SSC. Whether RF was present or not, ReTain treatment resulted in a significant decrease in starch pattern index. This indicates that ReTain did, in fact, delay maturity when maturity is based on firmness and starch pattern index. One interesting observation from the orchard B large-scale trial was that when RF was added to the ReTain treatment, color was significantly improved, firmness and starch pattern index were not altered but SSC significantly increased.

Discussion

Significant improvements in red color were observed with RF on both small and large experimental plots for young (3 to 4 years old) and mature (7 years old) bearing 'Gala' apple trees. Under normal growing conditions, upper canopy sun-exposed apple fruit are typically redder than lower canopy shaded fruit (Jackson, 1967). The use of RF might ensure that fruit from the lower canopy actually pack out rather than being marketed as a less profitable utility grade, sold for juice or culled altogether.

The quality of reflected light from the film was not different from direct sunlight, but it was reduced in intensity. Doud and Ferree (1980a) made similar observations in their field studies. Light reflected from the film was different in both quality and quantity from that reflected by the sod, however. This observation is consistent with our previous findings on peach (Layne et al., 2001). For measurements directly above the film or on a 45° angle to the film in the tree canopy, the higher corresponding phytochrome photoequilibrium values compared to that of the no film control treatment indicate that more of the phytochrome in the tree leaves and fruit skin should be in the FR absorb-

Table 4. The influence of reflective film and aminoethoxyvinylglycine (ReTain)[z] on color, size and maturity of 'Imperial Gala' apples in Orchard A, Gray Court, S.C.[y]

Experimental treatment: Film	Experimental treatment: ReTain	Red surface area (visual scale)[x]	Fruit diam (inches)[w]	Flesh firmness (lb-force)[v]	SSC (%)	Starch (visual scale)[u]
1998						
–[t]	+	2.33 b[s]	2.75	19.9	14.1	4.59
+	+	2.96 a	2.74	20.2	14.4	4.94
$LSD_{0.05}$		0.09	NS	NS	NS	NS
1999						
–	–	1.85 b	2.81	15.6 b	11.5	5.55
–	+	1.55 c	2.75	16.3 ab	11.6	5.68
+	+	2.12 a	2.78	16.5 a	11.9	5.75
$LSD_{0.05}$		0.11	NS	0.84	NS	NS

[z]ReTain is the commercial formulation of aminoethoxyvinylglycine (Valent Biosciences, Libertyville, Ill.).
[y]Percent red surface and fruit diameter data is the mean of 200 fruit per treatment; fruit maturity data [firmness, soluble solids concentration (SSC), and starch] is the mean of 40 fruit per treatment.
[x]Color scale: 1, 2, 3, and 4 = 0% to 25%, 26% to 50%, 51% to 75%, and 76% to 100% red surface, respectively.
[w]1.00 inch = 25.4 mm.
[v]1.0 lb-force = 0.225 N.
[u]Starch scale: 1 = 100% iodine staining to 6 = no iodine staining.
[t]Absence (–) or presence (+) of the experimental treatment of film or ReTain, respectively.
[s]Means within columns with different letters are significantly different at $P = 0.05$.

Table 5. The influence of reflective film and aminoethoxyvinylglycine (ReTain)[z] on color, size and maturity of 'Gala' apples in Orchard B, Monetta, S.C.[y]

Experimental treatment: Film	Experimental treatment: ReTain	Red surface area (visual scale)[x]	Fruit diam (inches)[w]	Flesh firmness (lb-force)[v]	SSC (%)	Starch (visual scale)[u]
–[t]	–	1.85 c[s]	2.71	17.0 b	13.2 bc	4.53 a
–	+	1.54 d	2.75	18.7 a	12.6 c	3.90 b
+	–	2.71 a	2.74	17.0 b	13.7 ab	4.74 a
+	+	2.41 b	2.71	18.7 a	13.9 a	3.99 b
$LSD_{0.05}$		0.14	NS	0.89	0.66	0.41

[z]ReTain is the commercial formulation of aminoethoxyvinylglycine (Valent Biosciences, Libertyville, Ill.).
[y]Percent red surface and fruit diameter data is the mean of 200 fruit per treatment; fruit maturity data [firmness, soluble solids concentration (SSC), and starch] is the mean of 40 fruit per treatment.
[x]Color scale: 1, 2, 3, and 4 = 0% to 25%, 26% to 50%, 51% to 75%, and 76% to 100% red surface, respectively.
[w]1.00 inch = 25.4 mm.
[v]1.0 lb-force = 0.225 N.
[u]Starch scale: 1 = 100% iodine staining to 6 = no iodine staining.
[t]Absence (–) or presence (+) of the experimental treatment of film or ReTain, respectively.
[s]Means within columns with different letters are significantly different at $P = 0.05$.

ing form which is the physiologically active form as compared to the R absorbing form (Cerny et al., 2000). This might favorably impact anthocyanin pigment production. In the tree canopy all three light parameters measured were higher for the RF as opposed to the control treatment. This altered light quality likely contributed to the color differences we observed. Green et al. (1995) estimated that *PPF* absorption by an apple canopy was increased by 40% when a reflective foil was used. Since the film also reflected more UV light, it is probable that this also positively impacted red skin coloration. Dong et al. (1995) found that red color of 'Royal Gala' apple could be increased in intensity following irradiation with UV light. Color differences were likely due to the combined effects of altered light quality and quantity.

Due to the problem of preharvest fruit abscission for 'Gala' in South Carolina, some commercial growers were experimenting with ReTain as a means to reduce preharvest fruit abscission and improve red skin coloration and postharvest quality. Although we did not quantify the impact of ReTain on preharvest drop, we observed substantially more fruit on the ground at harvest in the nontreated plots in comparison with those treated with ReTain. ReTain significantly delayed softening and starch degradation of 'Gala' apples in this study, which is similar to reports by others (Autio and Bramlage, 1982; Bangerth, 1978; Byers, 1997). However, fruit from trees treated with ReTain had less red skin color than nontreated fruit. For late season cultivars that hang longer on the tree, the maturity delay afforded by ReTain may enhance sun exposure on the tree thus improving red color. Under climatic conditions in South Carolina and especially for a summer apple cultivar such as 'Gala', ReTain would not be recommended for color improvement.

Since in earlier studies with peach (Layne et al., 2001) RF increased red skin coloration but advanced maturity there was concern that any color benefit from RF might also be associated with reduced efficacy of the ReTain treatment. In 2 years at Orchard A, RF significantly improved red coloration of ReTain-treated fruit without altering maturity. The same trend was observed at Orchard B but the color improvement was substantially greater at this site and there was a significant increase in fruit SSC. The primary difference between the Orchard B site and the Orchard A site was that the plot sizes were substantially larger [1 acre (0.4 ha) each] at Orchard B. Higher fruit SSC may have been due to increased whole canopy *PPF* absorption (Green et al., 1995) resulting in increased whole tree photosynthetic rates.

The combination of ReTain and RF may be a viable grower practice to produce 'Gala' in South Carolina. Due to the earliness of production of 'Gala' from South Carolina, growers can attain good market prices and the added cost of these two practices can be factored into a profitable production scheme. Although the use of good horticultural practices (i.e., proper dormant and summer pruning, tree training and fertilization) combined with RF should optimize the color potential that can be achieved in a particular environment, the maximum red color potential in apple is genetically controlled (Mancinelli, 1985), thus cultivar selection is critical.

One final caution we make to potential RF users, however, is that the increased heat load due to light reflected from the RF could result in drought stressing the tree if there was inadequate rainfall or if insufficient irrigation water was available during a particularly hot, sunny and dry period near harvest. Lack of sufficient water under such conditions could detrimentally affect fruit size and quality and under severe conditions lead to premature leaf and fruit abscission.

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