

A METHOD FOR BLIND NODE EVALUATION

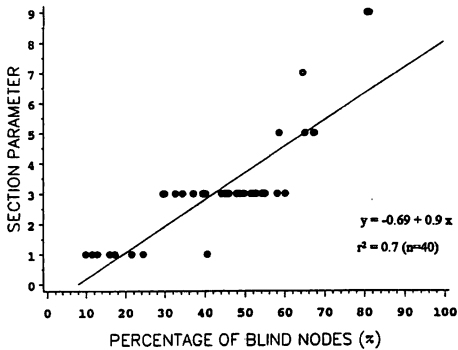


Figure 2. Regression of the section parameter method on the actual percentage of blind nodes.

is quick and reliable, it is useful for field evaluation of blind node propensity. The blind node propensity was genotype specific which would indicate that selection against high levels of blind nodes would lead to the development of peach cultivars with less blind nodes.

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In Situ Differences in Fruit Color Development of Six 'Delicious' Apple Strains

SUMAN SINGHA,¹ TARA A. BAUGHER² AND EDWIN C. TOWNSEND²

Abstract

Changes in fruit color of six 'Delicious' apple (*Malus domestica* Borkh.) strains were recorded in situ from 27 July through 21 September 1988 (149 days after full bloom). Fruit color was measured with a Minolta CR-200b portable tristimulus colorimeter at the midpoint between the stem and calyx end on fruit directly exposed to sunlight. Significant differences in color were observed among strains even at the first measurement date. Strains which had a darker red coloration at harvest tended to initiate earlier red color development. Strains varied in their rate of color development. In most strains rapid color development occurred between the middle of August and the first week of September, by which time the strains tended to approach their ultimate color.

Fruit color is an important attribute of 'Delicious' strains and it influences both consumer acceptance (4) and sales (15). Furthermore, surface color is an important criterion in establishing U.S. grade standards for apples (16)

and poor coloration remains an important cause for reduction in grade (1). Consequently, a major criterion in the selection of new strains is their higher red coloration (6). Besides genetic variations among strains, color development in fruit is influenced by both cultural and environmental factors. Environmental factors that are important in color development of fruit include temperature (5) and light (7, 11).

Singha et al. (1991a) reported wide variations in both the amount and the distribution of anthocyanin in fruit of ten 'Delicious' strains at harvest. High-coloring strains had a significantly higher anthocyanin concentration on both the blushed and nonblushed surface when compared to low-coloring strains. However, information is lacking on whether color intensity at harvest is

¹Department of Plant Science, U-67, The University of Connecticut, Storrs, CT 06269-4067.

²Division of Plant and Soil Sciences, West Virginia University, Morgantown, WV 26506-6108.

related to earliness of color development. Quantifying changes in fruit color during the season, and especially prior to harvest may also provide a useful harvest index, especially if this could be conducted using a rapid, nondestructive procedure which would make it possible to monitor the same fruit(s) over time.

The objectives of this study were to nondestructively measure *in situ* color changes in fruit of six 'Delicious' strains to determine whether earliness of color development is related to fruit color at harvest, and to compare variations in the rate of color development among strains.

Materials and Methods

This study utilized trees in the 'Delicious' apple strain evaluation block at the West Virginia Univ. Farm, Kearneysville. Trees spaced 4.9 x 6.1 m were planted in north-south-oriented rows on Hagerstown silt loam soil during 1981 and 1982. A ground cover of Kentucky-31 fescue was established between rows immediately after tree planting. Recommended herbicide and pesticide programs were followed, and all trees received uniform annual fertilizer applications. Trees were trained to a modified central leader by pruning during the dormant season.

Strains were selected based on variations in surface color at harvest (13) and included 'Ace,' 'Nured Royal,' 'Oregon Spur II,' 'Red Prince,' 'Ryanred' and 'Starkrimson.' Five fruit were tagged on each of 5 trees of each strain in each of two blocks in July 1988. Fruit were located approximately 1.5 to 2m above ground at the outer periphery of the tree. Fruit color measurements were made at approximately the same location on each fruit nine times from 27 July (93 DAFB) through harvest on 21 September (149 DAFB). Color measurements were made by placing the 8-mm-diameter measuring area of a Minolta CR-200b tristimulus colorimeter (Minolta, Ramsey, N.J.) at the

midpoint between the stem and calyx end on the fruit surface directly exposed to sunlight. The meter was calibrated at illuminant condition C (6774K) with a white standard prior to usage. To facilitate measuring as close to the same location at each measuring date, each fruit was marked at the shoulder with a small permanent ink orientation spot. Also, the area to be measured was gently wiped with a soft cloth prior to measurement to eliminate any variations in chromaticity values due to dust or spray residues. Fruit chromaticity was recorded in Commission Internationale d'Eclairage L^* , a^* , and b^* color space coordinates (8). In this system L^* represents the value (lightness) of color, it is small for dark colors and large for light colors; a^* is negative for green and positive for red, whereas b^* is negative for blue and positive for yellow. The color difference (E^*_{ab}) between any two sampling dates was computed as $E^*_{ab} = L^{*2} + a^{*2} + b^{*2}$. Tree means for each color variable were analyzed as a randomized complete block design using the General Linear Model (GLM) procedure of SAS (12). Least significant difference (LSD) was computed for each sampling date from the error mean square.

Results and Discussion

Significant differences in fruit color were observed among strains even on the first measurement date (Fig. 1). An examination of a^* , which ranges from green ($-a^*$) to red ($+a^*$), indicates that the six strains could be separated into three groups on this sampling date. 'Starkrimson' and 'Red Prince' had a more intense green coloration (a more negative a^*) than 'Ace' and 'Oregon Spur II,' whereas 'Nured Royal' and 'Ryanred' formed an intermediate group (Fig. 1). These differences were maintained through August. Further, fruit of 'Ace' and 'Oregon Spur II' developed positive a^* values by the 11 August sampling date, whereas 'Red Prince' and 'Starkrimson' reached sim-

ilar values almost 2 weeks later (on 25 August). Although fruit of 'Starkrimson' were still green on 16 August, they developed red color very rapidly by 8 September. Depending on strain, the a^* values peaked on 8 September or 16 September and showed a slight

decline by 21 September. The quantified difference in fruit red color development are in general agreement with visual observations of these strains. 'Ace' and 'Oregon Spur II' show red coloration earlier than 'Red Prince' and 'Starkrimson' which do not initiate

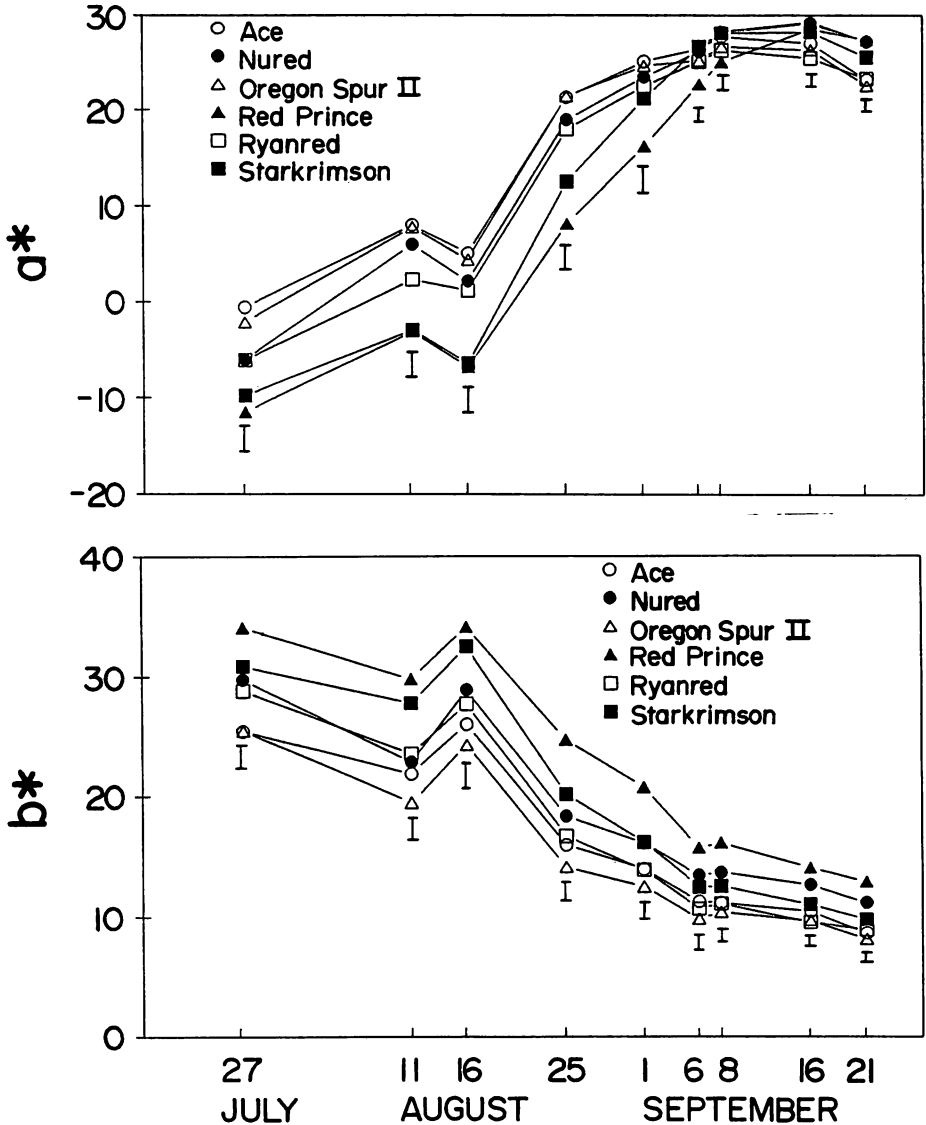


Figure 1. Seasonal change in a^* , and b^* in 'Delicious' apple strains in situ. Vertical bars represent LSD ($P = 0.05$).

color development until much later.

The difference among strains in b^* (a measure of yellowness) were inverse to those for a^* (Fig. 1). On 27 July, 'Red Prince' and 'Starkrimson' had a more intense yellow coloration (higher b^* value) as compared to 'Ace' and

'Oregon Spur II'. These differences tended to be maintained through most the growing season. Changes in the a^*/b^* (Fig. 2) ratio followed a trend similar to that observed with a^* until 25 August. However, unlike a^* , 'Ace' and 'Oregon Spur II' continued to

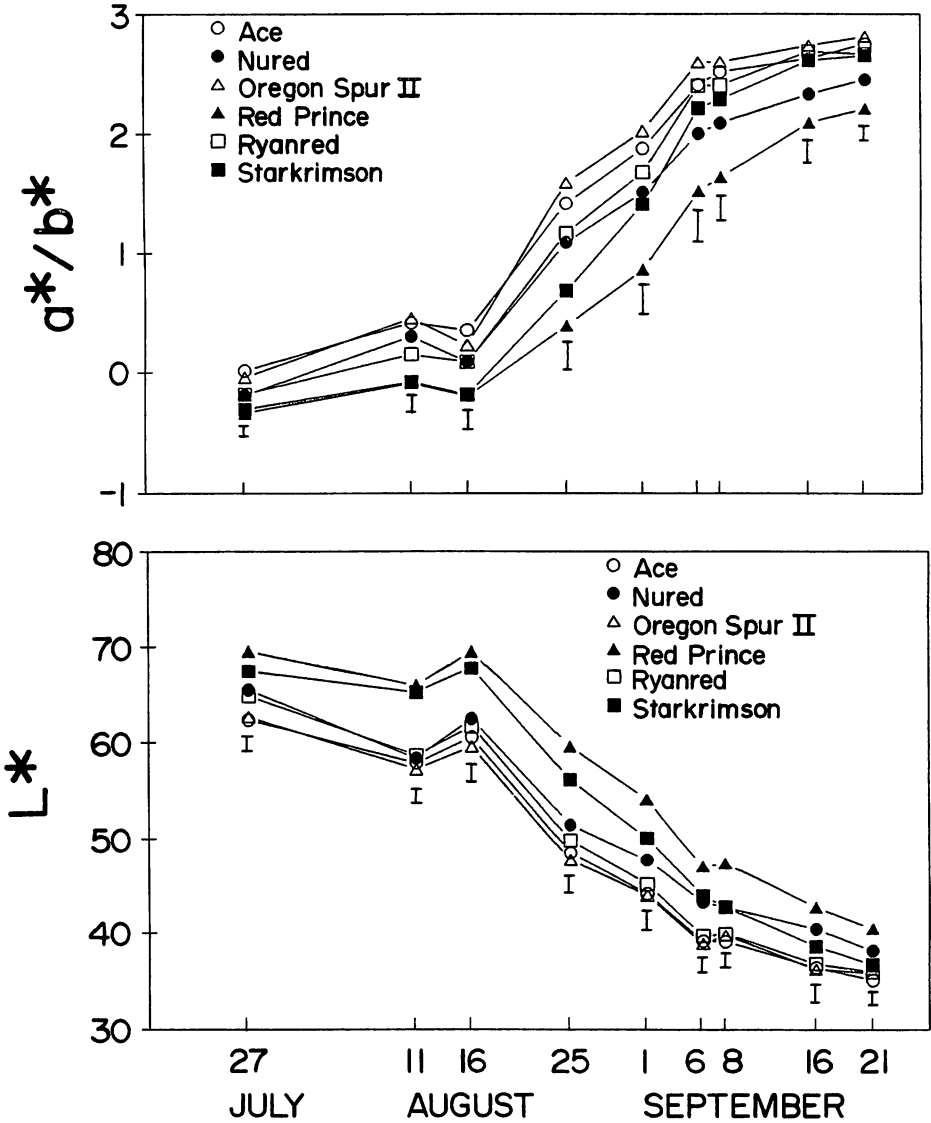


Figure 2. Seasonal change in a^*/b^* ratio, and L^* in 'Delicious' apple strains in situ. Vertical bars represent LSD ($P = 0.05$).

have a significantly higher a^*/b^* ratio than either 'Red Prince' or 'Nured Royal' during September, indicating a higher level of yellow color in the latter two strains. Singha et al. (1991b) reported that the instrumentally measured a^*/b^* ratio effectively relates to visual ratings of fruit. Fruit of strains like 'Oregon Spur II' which have a high a^*/b^* ratio are rated much higher than strains like 'Red Prince' with a lower a^*/b^* ratio (14). It is also interesting to note that a^* relates poorly to both the color panel rating, and to the anthocyanin content of the fruit skin (13) and consequently should not be used as a harvest guide. 'Ace' and 'Oregon Spur II' developed a darker red coloration (smaller L^*) than 'Red Prince' and 'Starkrimson' even at the time of the first measurement in July, and this difference was maintained through 16 September (Fig. 2). Thus, not only do fruit of 'Ace' and 'Oregon Spur II' develop red coloration earlier than other strains (especially 'Red Prince' and 'Starkrimson'), but these

strains have a darker coloration than low coloring strains like 'Red Prince' and 'Nured Royal' throughout the season and at harvest. The anthocyanin content of the fruit skin of 'Oregon Spur II' and 'Ace' which have been selected for their superior coloration was reported to be significantly higher than that of low-coloring strains like 'Red Prince' (13). Furthermore, color changes when fruit darken to $L^* < 50$ are closely related to changes in anthocyanin content (13).

All fruit in this study were harvested on September 21 (149 days after full bloom) and it was assumed that the strains had reached optimum color development. A single harvest date was used because of the inability to establish a sequence of ripening for these strains based on soluble solids, starch index or firmness either as separate or combined indices (2). Based on the total color difference (E^*_{ab}) (between color at harvest and each preceding sampling date, it is obvious that rapid color development occurs

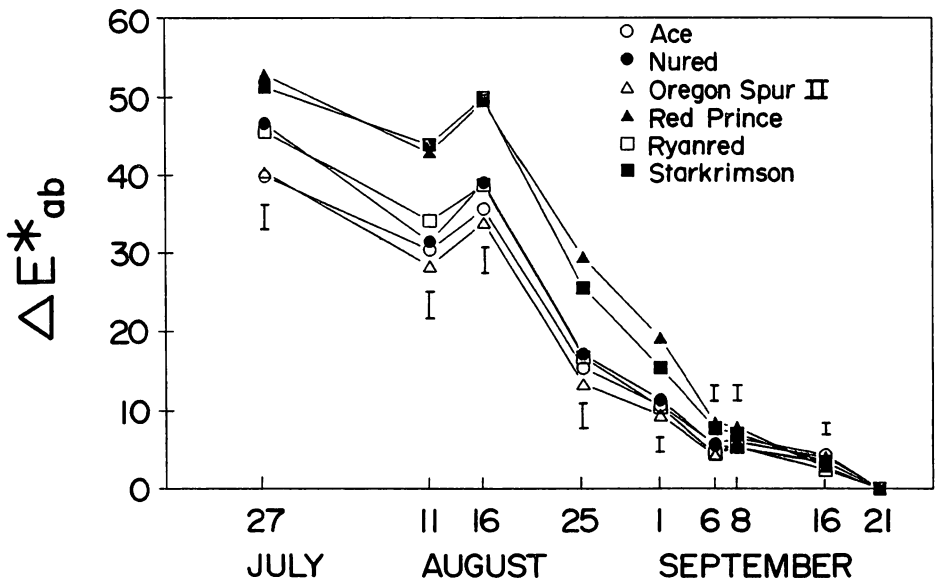


Figure 3. Rate of change on color development in 'Delicious' apple strains in situ. Vertical bars represent LSD ($P = 0.05$).

between the middle of August and the first week of September, by which time the strains tend to approach their ultimate color (Fig. 3). Once fruit achieve satisfactory coloration which qualifies them for the desired U.S. grade standard, decision to harvest should be predicated upon firmness and soluble solids values desired for shipping (9, 10). Given the previously established relationship between anthocyanin concentration and chromaticity parameters (13), the present study supports the conclusions of Chalmers et al. (1973) that it may be possible to utilize the rate of change in anthocyanin accumulation as an index of maturity in red apple cultivars.

This study demonstrates that significant differences exist between strains both on earliness and rate of red color development. Early coloring strains tend to have better developed color at harvest. Monitoring the rate of change of parameters such as the a^*/b^* ratio or L^* or a combination of these in the period prior to harvest may prove to be a useful harvest guide, and needs to be further investigated.

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1993 Apple Cultivar Trial

A 23-page report on the performance of new apple cultivars grown at the Washington State University apple test plot at Prosser during the 1993 season has just been completed. The publication contains data on bloom and harvest dates, fruit size and maturity (firmness, soluble solids, and starch conversion), as well as a brief evaluation of 68 current cultivars and selections.

Copies may be ordered at a cost of \$5.00 each (postage included) from Washington State University, Mount Vernon Unit, 1468 Memorial Highway, Mount Vernon, WA 98273. Checks should be made payable to Washington State University.