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The Effect of Hail Nets and Ethephon on Color Development of 'Redchief Delicious' Apple Fruit in the Highlands of Chihuahua, Mexico.

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Abstract

Fruit color in 'Redchief Delicious' apples under hail nets and uncovered trees was measured by luminosity (L*) and hue (°h) values from July to September, 1999 including harvest time in all treatments. Treatments consisted of trees under black and white nets and controls without nets during the growing season, trees in each treatment were foliar sprayed or not with ethephon before harvest. Final fruit color on trees without hail nets had a mean L* value of 44.1 and °h value of 38.8. Trees under black hail nets yielded a mean L* value of 48.4 with an °h value of 53.0, while for white hail nets values were: L*; 44.8 and °h; 41.0 There were no statistical differences between cardinal orientation. Fruit from ethephon sprayed trees did not show statistical differences between L* and °h values within sampling dates at harvest. There was a reduction of both, incident solar light and final fruit color due to either black or white hail nets over the trees.

Introduction

Apple production in the State of Chihuahua, México reached 217 thousand tons for over 57, 500 acres (ca. 25 thousand hectares) in 1997. This yield represented 47% of Mexico's apple production. The apple growing area of Cuauhtémoc, Chih. is the center of the region and largest production area and approximately 250,000 jobs are generated by the industry. The most important apple cultivars in the area are 'Delicious' and its mutations followed by 'Golden Delicious' and 'Rome Beauty'. In fresh fruit market, fruit appearance is an important factor for sales. Fruit appearance and hence sales is largely based on red color. Strains of 'Delicious' such as 'Redchief' are preferred because of their ability to produce highly colored fruit.

Due to climatic characteristics of the area growers are obligated to use hail nets to protect trees and fruit against damage during the growing season. The area has an average of three hail storms per growing season. Most of the hail nets used are black, which greatly reduces incident solar light, and may have a negative impact on development and final fruit color. Fruit with inadequate marketable color at harvest time, varies with year, with an average of 10-15%, decreasing fruit market value. Growers therefore use ethephon foliar sprays to improve fruit color.

Objectives of this research were to determine the effect of two different colored hail nets, black and white, on the development of and final fruit red color for 'Redchief Delicious' apples, as compared to fruit on trees without nets. The interaction of the use of ethephon was also evaluated.

Materials and Methods

The experimental plot was located in Cuauhtémoc, Chih. México. Seven-year-old 'Redchief Delicious' apple trees on MM.106 rootstock, and spaced 4.0 x 5.0 m were used for this experiment. A total of eighteen trees under a completely randomized design were utilized, with six trees covered with white nets; six trees covered with black nets, and six trees left uncovered as controls (UC). Three trees of each treatment were treated with a foliar spray of ethephon once before harvest, and two apples were sampled from the north and

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south sides of each tree. Treatments were set in the orchard by individually covering each tree, either with white or black hail nets, while control trees were left uncovered. Due to their young age, trees used in the experiment had small canopies, with minimal shading within individual trees and rows. Rows were oriented N-S. Incident photosynthetic photon flux (PPF) measurements were made using a Line Quantum Sensor [LQS] (Li-191 SB Li-Cor Inc. Lincoln, Nebraska, 1990). The LQS was placed in the orchard, outside the tree rows, on a leveled support in the center of a N-S oriented structure holding the net, either white or black, similar to those used in commercial orchards. PPF measurements were those of sunlight going through the black or white color nets. Also, Incident PPF absolute measurements above the nets was also measured outside the nets, considering this reading as the sunlight in the orchard on uncovered trees. PPF was measured daily at noon, with a total of ten days taking light readings for each net treatment and the uncovered controls. Fruit from all treatments were sampled on July 14, 22 and 29; August 17 and 26, and September 8 (harvest time) 1999. On September 8, fruit from ethephon treated and untreated trees were sampled for fruit color readings. Fruit skin color was measured on the same day of sampling using the CIE (Commission Internationale d'Eclairage) L*, a* and b* color space coordinates (7) using a Minolta CR-300 colorimeter. a* and b* values were transformed to °h [arctangent (b/a)] values. Hue negative values were transformed using the following formula; degrees [arctan (b/a)] + 180. Luminosity (L*) and hue (°h) values were chosen to define color, since both terms are the most related to consumer preference and color definition. Fruit color was measured on the reddest section and on the opposite side of each fruit, with the above instrument, calibrated with a white color standard plate (Y= 93.2; x= .3133 and y= .3192). Fruits were sampled from the N and S side of each tree, N as the less illuminated side and S as the most illuminated one, from the tree canopy periphery, at an average height of 1.8 m, to eliminate shading due to tree shape. Three trees per treatment received foliar spray on September 3, 1999, before harvest with a mixture of 360 ml of Ethrel® (ethephon), plus 160 ml of NAA and 440 g of an adjuvant to acidify the mixture in 1, 000 l of water. The mixture was applied on September 3, 1999, according to the grower's orchard management schedule. Mean temperatures during and after ethephon application had an average of 22.7°C. The remainder of the trees were left untreated. Experimental design was a completely randomized with factorial arrangement of 3 levels of net, seven dates of sampling and two sides of the tree, with six replications. Statistical analysis was done by ANOVA (SAS Institute, Cary, N. C. USA). ANOVA was performed for the last date of sample (harvest date), dates of sampling, as well as per tree sides (cardinal orientation). Ethephon sprayed and non-sprayed fruit color readings were included in the ANOVA for dates of sampling. Statistically significant value means were compared by Tukey's Studentized Range at 5% level.

Results and Discussion

Incident PPF measurements gave the following mean values: 896 μmoles•m^2•sec^{-1}, 1252 μmoles•m^2•sec-1 and 2000 μmoles•m^2•sec^{-1} on trees under black and white nets and uncovered controls, respectively. These PPF readings were the same values as the PPF readings on the tree canopies of each net treatment (7).

Final fruit color was reduced on trees under black nets with an L value of 48.4 and an °h value of 53.0, as compared to L and °h values of 44.8 and 44.1 and 41.0 and 38.8, for final fruit color on trees under white nets and uncovered controls, respectively. Table 1. Lower L* and °h values translate into a darker, redder fruit color (4), respectively. L* and °h values define consumer preferences regarding fruit color (3, 8). Differences in PPF values received by the fruit on trees under the different net treatments had an effect on final fruit color among treatments.

Table 1. Mean L* and °h values on 'Redchief Delicious' apples under different treatments in Cuauhtémoc, Chih. Mexica. 1999.

Treatments	L* mean values[1]	°h mean values[1]
Hail Nets		
Black	48.4 a	53.0 a
White	44.8 b	41.0 b
Control	44.1 b	38.8 b
Tree side		
South	45.9 n.s.	44.7 n.s.
North	45.5	43.8
Dates of Sampling		
July 14	54.1 a	70.7 a
July 29	51.8 a	62.7 a
July 22	49.8 a	54.8 b
August 26	42.8 b	33.7 c
August 17	42.0 b	33.8 c
September 8[Y]	39.8 b	25.7 c
September 8	39.6 b	28.4 c
Source of Variation and Interactions	F value	
Nets	8.44*	10.21**
Dates (Ethephon included)	24.78**	24.55**
Nets X Dates	0.81 n.s.	0.72 n.s.
Tree Side	0.22 n.s.	0.12 n.s.
Nets X Tree Side	0.88 n.s.	0.88 n.s.
Nets X Dates XTree Side	0.50 n.s.	0.37 n.s.

[1]Tukey's Studentized Range at 5% level.
[Y]Ethephon treated fruit

As far as final fruit color depending on fruit cardinal orientation within the tree canopy, no statistical differences were found between south and north sides of the tree, L* south value was 45.9 and 45.5 for the north side, for °h values; south side = 44.7 and north side = 43.8 Table 1. These results may be explained by the fact that trees used in this experiment were young with open tree canopies, which allowed an even distribution of sunlight throughout the tree (6).

Dates of sampling showed statistical differences among them, Table 1. Mean values for L and °h on the last date of sampling, September 8, were not statistically different for ethephon treated and untreated fruit. Ethephon treated fruit had L and °h values of 39.8 and 25.7, respectively; while ethephon non- treated fruit had an L value of 39.6 and an °h value of 28.4. Values for L and °h for dates of sampling in July were statistically different than those in August and September. These results may be due to the fact that sampling for fruit color readings were started early in the season, when red color development on the fruit is just starting to develop. For ethephon treatments, results can be influenced by dose and application time (1).

There were no statistically significant interactions among the main factors evaluated for final fruit color, Table 1.

Figures a and b, show the behavior during the growing season for L and °h color components, respectively. Both graphs include means for ethephon treated and untreated fruit for September 8. There were no statistical differences among treatments per sampling dates, neither between final fruit color values (L and hue) for ethephon treated and untreated fruit.

Tendency shown in net treatments indicates a better final fruit color, lower L* and hue (°h) values, for uncovered controls which received full PPF, followed by white net treatments, higher L* and °h values than controls, and finally black net treatments with the less red colored fruit, greatest L* and °h values among treatments. These results had a relationship with amount of incident PPF transmitted

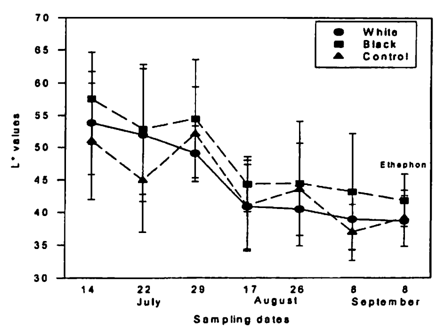

Figure a. L* mean values during the growing season for 'Redchief Delicious' apples under different treatments. Cuauhtémoc, Chih. Mexico. 1999.

through and received by the tree canopy for either black or white nets and on uncovered trees (7). Lower L* and °h values translate into a darker, redder fruit color (4), respectively.

A lower PPF that had reached the fruit under black nets resulted in the highest L and °h values, since their red color was less developed (see also Figures a and b), as compared to white net covered trees and uncovered controls. Final fruit color was better in fruits from trees under white nets than those in trees under black nets, with best color on fruit on uncovered trees (2, 5).

Apple orchards in this area receive about 2,000 μmoles•m^2•sec^{-1} of PPF. Fruit under black nets, which reduce PPF by 50%, also reduced final fruit color. On the other hand, PPF is sufficient to achieve the cultivar's characteristic color (2, 5, 6) under white color hail nets.

Conclusions

The use of black hail nets reduced PPF and had a reducing effect on final fruit color, as measured by L and h color components. Final fruit color was not affected by ethephon or by side of the tree.

Literature Cited

1. Blanpied, G.D., C. G. Forshey, W. C. Stiles, D. W. Green, W. J. Lord, and W. J. Bramlage. 1975. Use of ethephon to stimulate red color without hastening ripening of 'McIntosh' apples. J. Amer. Soc. Hort. Sci. 100(4):379-381
2. Campbell, R. and R. P. Marini. 1992. Light environment and time of harvest affect 'Delicious' apple fruit quality characteristics. J. Amer. Soc. Hort. Sci. 117(4):551-557.
3. Crassweller, R. M., H.L. Braun, T.A. Baugher, G.M. Greene II, and R.A. Hollendar. 1991. Color evaluations of 'Delicious' strains. Fruit Var. J. 45(2):114-120
4. Ferree, D. C. and J. C. Schmid. 2001. An evaluation of 'Melrose' strains and selections. J. Amer. Pomol. Soc. 55(2):89-94
5. Robinson, T.L.; E.J. Seeley, and B.H. Barritt. 1983.Effect of light environment and spur age on 'Delicious' apple fruit size and quality. J. Amer. Soc. Hort. Sci. 108(5):855-861
6. Rom, C.R. and B. H. Barritt. 1989. Light interception and utilization in orchards. Chapter 3. In: Intensive orcharding, managing your high production apple planting. B. Peterson, technical editor. Good Fruit Grower, Yakima, WA. USA 1989.
7. Romo, A. 2000. "Influencia de la arquitectura del dosel y uso de mallas antigranizo en el microclima y fisiologia en manzano 'Starkrimson'. M. S. Thesis. Universidad AutÛnoma de Chihuahua. Chihuahua, Chih. Mèxico.
8. Singha, S.; E.C. Townsend, and T.A. Baugher. 1991. Relationship between visual rating and chromaticity values in 'Delicious' apple strains. Fruit Var. J. 45(1):33-36.

Fungicides and GA on Russet

Four foliar applications of captan, metiram, the strobilurins Kresoxim-methyl, trifloxy strobin, azoxystrobin or the polyoxim B compound Polar from green tip stage to the end of petal fall gave reduction in russet but not eliminating it. Tank mixing GA 4+7 with captan or the strobilurins did not improve russet control. Fruit in the upper part of the tree had significantly more russet than fruit in the lower part of the tree. Russet was more severe on fruits of trees on the west side of the row than on the east side. Thus factors other than fungicides which may act by reducing russet inducing microorganisms, are involved in russet development. From Reuveni et al 2001, J. Hort. Sci. Biotechn 76(5):636-640.