JOURNAL AMERICAN POMOLOGICAL SOCIETY

A Publication of the American Pomological Society

July 2000 — Volume 54 — Number 3

CONTENTS

Published by

THE AMERICAN POMOLOGICAL SOCIETY

Journal American Pomological Society (ISSN 1527-3741) is published by the American Pomological Society as an annual volume of 4 issues, in January, April, July and October. Membership ($30.00 per year or $80 for 3 years) in the Society includes a volume of the Journal. Most back issues are available at various rates. Library subscriptions are $30.00 per year for 4 issues. Paid renewals not received in the office of the Business Manager by January 1 will be temporarily suspended until payment is received.

Editorial Office: Manuscripts and correspondence concerning editorial matters should be addressed to the Editor: Dr. David C. Ferree, Department of Horticulture, Ohio Agriculture Research and Development Center, Wooster, OH 44691. Phone: (330) 263-3813. Manuscripts submitted for publication in *Journal American Pomological Society* are accepted after recommendation of at least two editorial reviewers.

Postmaster: Send address changes to the publishing office.

Publishing Office: American Pomological Society, 102 Tyson Building, University Park, PA 16802. Periodicals postage paid at State College, PA 16801.

Business Office: Correspondence regarding subscriptions, advertising, back issues, and Society membership should be addressed to the Business Manager: Dr. Robert M. Crassweller, 102 Tyson Building, University Park, PA 16802. Phone: (814)863-6163. E-mail aps@psu.edu.

Page Charges: A charge of $60.00 per page ($30.00 per half page) plus cost of engravings will be made to authors for those articles constituting publication of research.

Society Affairs: Matters relating to the general operation of the Society, awards, committee activities and meetings should be addressed to the Secretary: Dr. J. R. Schupp, New York Hudson Valley Lab, P.O. Box 727, Highland, NY 12528.

Journal of American Pomological Society 54(3):118-122 2000

Influence of In-Season Foliar Calcium Sprays on Fruit Quality and Surface Discoloration Incidence of Peaches and Nectarines

CARLOS H. CRISOSTO,[1] KEVIN R. DAY,[2] R. SCOTT JOHNSON,[1] AND DAVID GARNER[1]

Abstract

Foliar calcium sprays applied every 14 days, starting two weeks after full bloom and continuing until one week before harvest, did not reduce surface discoloration or increase fruit quality of mid- or late-season peach and nectarine cultivars. Multiple commercial calcium foliar sprays did not affect fruit soluble solids concentration (SSC), fruit firmness, fruit internal breakdown, and fruit flesh calcium concentration at harvest. Calcium concentration in the skin of the fruit was raised in three of the four varieties studied, leaf calcium was increased in two of the late cultivars.

Introduction

Surface discoloration, or inking, of peach and nectarine fruit has become an increasing problem during the last two decades in California and in other stone fruit production areas including Washington, Colorado, New Jersey and Chile. Surface discoloration symptoms appear as either dark black, dark brown, orange, or tan spots and stripes. This surface discoloration is restricted to the skin and never affects the fruit flesh.

Of the fruit shipped to the New York market between 1972 and 1975, nearly 16% of the peaches and 13% of the nectarines showed surface discoloration problems (1). In March 1991, we sent a survey to peach and nectarine producers in California's southern San Joaquin Valley area to ascertain at which step during harvest and postharvest handling operations they first noticed surface discoloration. Twenty-six percent of the respondents first observed surface discoloration just after picking while the fruit was still in the bins, 10% when it arrived at the packinghouse, 38% during the packing operations, and 5% upon leaving the packinghouse. High surface discoloration levels, in some cases approaching 60%, were reported during packinghouse sorting operations.

Previous research has demonstrated that surface discoloration occurs as a consequence of preharvest contamination combined with physical damage that occurs during fruit handling and transport (2). Anatomical studies comparing healthy with naturally and/or induced surface discoloration tissues, using light microscopy and scanning electron microscopy, demonstrated that surface abrasion was the primary physical injury associated with skin discoloration (2). Epidermal cells within the discolored spots were broken but those in non-discolored areas were intact. Flesh tissue cells (hypodermis and mesocarp) underneath the epidermis were intact in both cases. Postharvest vibration and rubbing treatments increased surface discoloration supporting our hypothesis that tissue damage is a requirement for surface discoloration development (2, 3).

Laboratory studies support our premise that contamination is also necessary for the development of surface discoloration (3). We demonstrated that only those fruit discs that were abraded developed dark discoloration after being exposed to different metallic ion concentrations. Ions tested included iron, aluminum, copper, tin, zinc, and sodium. Fruit discs that were not abraded were not discolored when treated with these metallic ions.

It is known that calcium maintains cell wall structure, retains fruit firmness, delays ripening and senescence, and helps reduce susceptibility to fruit physical damage. Previous research suggests that calcium sprays may be beneficial for apples and peaches growing in others regions of the United States (4,6). Based on this information some growers have hypothesized that foliar calcium sprays may be helpful in reducing or preventing surface discoloration. However, while there are calcium formulations listing label recommendations for "improving fruit quality," there are no such recommendations given for reducing surface discoloration.

Because of a lack of data under California conditions to support this hypothesis we decided to investigate the role of foliar calcium applications on peach and nectarine fruit quality and surface discoloration incidence.

Materials and Methods

'Flavorcrest,' 'Elegant Lady' and 'Cal Red' peaches and 'Flaming Red' nectarines from mature orchards in the northern Tulare County area with a history of surface discoloration were used in this study. Our prior research determined that these cultivars are all highly susceptible to surface discoloration. Based on label recommended rates, and on current grower practice, we designed our treatments to include varied application timing, rates, and calcium sources. All calcium treatments were then applied in 100 gallons of water per acre by air-blast sprayer. Treatments are summarized in Table 1.

Statistical Design and Analysis

In the 'Flavorcrest' and 'Elegant Lady' trials, spray treatments were applied to complete rows using a completely randomized design. Two non-sprayed rows were left as a border between treated rows. In the 'Cal Red' and 'Flaming Red' orchards, experimental units were randomly assigned to six tree groups within each row. All treatments were replicated three times. Postharvest data was statistically analyzed by ANOVA using SAS program (SAS Institute, Cary, NC).

Fruit Quality Evaluation

For each variety, 100 fruit per replicate were picked at commercial maturity as determined by ground color requirements established by the California Tree Fruit Agreement. Sun exposed fruit, located on the middle of the east side of the tree canopy, were collected for evaluation. Twenty of these fruit were used for the measurement of fruit quality (flesh firmness and SSC) at harvest. Flesh firmness was measured using a U.C. firmness tester with an 8-mm tip (Western Industrial Supply, San Francisco, CA). Skin from opposite cheeks of each fruit was removed and flesh firmness calculated as an average of two measurements per fruit. A wedge from each fruit was then removed and combined with others within the replicate to form a composite sample. From this composite sample, juice was extracted with a hand press, filtered through cheesecloth, and SSC measured with a temperature compensating refractometer (Cambridge Instruments, Buffalo, NY).

Aggregate surface discoloration area (ASDA), an indication of total surface discoloration incidence, was determined by measuring the affected area of each fruit surface with a 10 mm loop (78.5 mm^2). The number of fruit exceeding commercial standards for surface discoloration (>80 mm^2 total affected area) were counted and expressed as percent of fruit affected.

The remaining twenty fruit per replicate were held in a temperature controlled room at 68°F (20°C) and 80% RH for three days prior to surface discoloration evaluations. Surface discoloration incidence was measured both as the percentage of fruit affected and as ASDA.

Storage Evaluation

Storage trials were performed on the cultivars 'Flavorcrest' and 'Elegant Lady.' For these tests, 40 fruit per replicate were conventionally stored at 32°F (0°C), and 90% RH. Twenty fruit per replicate were

[1]Department of Pomology, One Shields Avenue, University of California, Davis, Davis, CA 95616 located at the Kearney Agricultural Center, 9240 South Riverbend Avenue, Parlier, CA 93648.
[2]University of California Cooperative Extension Tulare County, 2500 West Burrel Avenue, Visalia, CA 93291.
The authors wish to thank George Brothers Packing Company, Sultana, CA, Micky George, Lee Garispe, Charlie Roque, and John Kalander for their assistance with this project.

Table 1. Summary of calcium spray treatments.

Cultivar	Application dates	Calcium source	Rates (total lbs calcium/acre/season)	Harvest date
Flavorcrest	3/28 4/8, 4/20 5/15, 5/27	Link Calcium 6% (Wilbur-Ellis)	3.10	June
Flavorcrest	5/27	Link Calcium 6% (Wilbur-Ellis)	0.62	June
Elegant Lady	3/28 4/8, 4/20 5/15, 5/27 6/15	Link Calcium 6% (Wilbur-Ellis)	3.72	July
Elegant Lady	5/27 6/15	Link Calcium 6% (Wilbur-Ellis)	1.25	July
Cal Red	3/24 4/7, 4/21 5/11, 5/22 6/4, 6/26 7/20	Stopit (7%) (Shield.Brite)	10.56	August
Flaming Red	3/24 4/7, 4/21 5/11, 5/22 6/4, 6/26 7/20	Stopit (7%) (Shield.Brite)	10.56	August

removed at weeks 2 and 4 of storage for evaluation. Fruit were allowed to reach room temperature and then Flesh firmness and SSC were measured on ten of the fruit while the other ten fruit were ripened at 68°F (20°C) for 5-7 days prior to evaluation for internal breakdown (IB). IB symptoms are characterized by flesh browning and changes in texture including loss of juiciness, and increased mealiness and leatheriness. These observations were made on the mesocarp around the pit immediately after the fruit were cut transversely along the plane of the suture.

Tissue Mineral Content

At harvest, leaf, skin, and flesh calcium concentration was measured. Samples consisted of 20 natural fruit and 30 leaves per replicate. Fruit samples were washed and scrubbed to remove the peach fuzz and any calcium residues remaining on the surface. Leaf samples were washed, dried, and ground before being sent to the UC Davis plant tissue laboratory.

Results and Discussion

Fruit Quality and Storage Evaluation

Calcium applied either one or five times on 'Flavorcrest' and two or six times on 'Elegant Lady' did not reduce the percentage of fruit with surface discoloration or ASDA (data not shown). Eight calcium applications during the growing season did not reduce surface discoloration incidence on 'Flaming Red' nectarine or 'Cal Red' peach (Table 2).

Flesh firmness, SSC measured at harvest, and IB measured after 2 and 4 weeks storage period on ripe fruit, were not affected by any of the calcium spray treatments on 'Flavorcrest' or 'Elegant Lady.' Flesh internal browning and mealiness were not detected on ripened fruit regardless of treatment when evaluated after 2 and 4 weeks storage (Table 3).

Table 2. Effect of calcium spray treatments on tissue calcium concentration of 'Flavorcrest,' 'Elegant Lady,' and 'Cal Red' peaches and 'Flaming Red' nectarine.

Cultivar	Rate (lbs calcium/ acre/season)	Surface discoloration ASDA[Z]	%[Y]
'Flavorcrest'	0.00	90.3	58
	0.62	36.9	40
	3.10	54.2	53
LSD 0.05		NS[X]	NS
'Elegant Lady'	0.00	78.5	73
	1.25	56.5	49
	3.72	76.9	73
LSD 0.05		NS	NS
'Cal Red'	0.00	32.9	23
	10.56	43.1	40
LSD 0.05		NS	NS
'Flaming Red'	0.00	50.9	30
	10.56	61.2	45
LSD 0.05		NS	NS

[Z]ASDA = Aggregate surface discoloration area; total area of individual fruit affected by surface discoloration in mm².
[Y]Percent of fruit presenting surface discoloration in excess of grade standards.
[X]NS = no significant differences, according to ANOVA and LSD mean separation test at 5% level.

Tissue Mineral Content

Calcium concentration was higher in the skin than in the flesh tissue (Table 4). Leaf calcium concentration was always higher than calcium in the fruit. Leaf calcium concentration was significantly increased by calcium foliar sprays only on the late cultivars 'Cal Red' peach and 'Flaming Red' nectarine but not in the two earlier harvest cultivars. The two late cultivars received a total of eight calcium applications. The lack of calcium uptake by 'Flavorcrest' and 'Elegant Lady' leaves may be related to the low number of foliar sprays (1-6) combined with the fact that calcium concentration in peach leaves is generally high (approx. 3%). Thus, these multiple calcium sprays of approximately 400 ppm (0.04%) each had likely no effect on increasing leaf levels in any of these mid season cultivars.

Foliar calcium sprays increased skin concentration in mature 'Flavorcrest,' 'Cal Red' and 'Flaming Red' but had no affect on 'Elegant Lady' peach. In the four cultivars used, foliar calcium sprays did not increase flesh calcium content (Table 4). At harvest, skin calcium of untreated fruit ranged from 300-650 ppm and flesh calcium was approximately 300 ppm. As much as, one might expect eight sprays of approximately 400 ppm calcium each to be sufficient to increase flesh calcium concentrations. This lack of calcium uptake by the fruit flesh suggests that calcium mobility is extremely limited within peach and nectarine fruit tissue under California orchard condition.

Table 3. Effect of calcium spray treatments on 'Flavorcrest' and 'Elegant Lady' peach quality characteristics.

Treatment rate Lbs/acre/season	SSC (%) harvest	Fruit firmness (pounds) Week 0	Week 2	Week 4	Internal breakdown I.B.[Z] (score)	Mealiness (%)
Flavorcrest						
0	9.5	10.6	10.4	10.2	1.0	0
1.25	10.1	10.7	9.9	10.4	1.0	0
3.72	9.7	11.8	10.5	10.0	1.0	0
LSD 0.05	NS[X]	NS	NS	NS	NS	NS
Elegant Lady						
0	10.5	12.7	13.2	10.0	1.5	0
1.25	10.6	13.3	13.1	10.3	1.6	0
3.72	9.3	13.6	13.7	10.9	1.1	0
LSD 0.05	NS	NS	NS	NS	NS	NS

[Z]Internal Browning: 1 = None, 2 = Very slight browning in the pit cavity; 3 = Very slight browning in the pit cavity and surrounding tissue; 4 = Moderate browning on less than 50% of the flesh; 5 = Severe browning on 50 to 75% of the flesh; 6 = Extreme browning covering most of the flesh.
[Y]Percent of fruit presenting mealiness
[X]NS = no significant differences, according to ANOVA and LSD mean separation test at 5% level

Table 4. Effect of calcium spray treatments on tissue calcium concentration of mature 'Flavorcrest,' 'Elegant Lady,' and 'Cal Red' peaches and 'Flaming Red' nectarine.

Treatment rate (lbs/acre/season)	Leaf (% DW)	Fruit skin (g/g DW)	Fruit flesh (g/g DW)
'Flavorcrest'		6/01/92	
0	2.57	600a	300
1.25	2.72	700a	300
3.72	2.29	1,000b	300
LSD 0.05	NS[z]	*	NS
'Elegant Lady'		6/25/92	
0	3.3	500	300
1.25	3.0	600	300
3.72	3.2	600	300
LSD 0.05	NS	NS	NS
'Cal Red'		7/28/92	
0	2.82a	300a	200
10.56	3.15b	500b	200
13.12	2.80a	500b	200
LSD 0.05	*	NS	NS
'Flaming Red'		7/28/92	
0	2.9	650a	230
10.56	3.1	800b	300
LSD 0.05	*	NS	NS

[z]NS = no significant differences, according to ANOVA and LSD mean separation test at 5% level, * - significant differences among means within the columns according to the LSD mean separation test at 5% level.

Since none of the foliar calcium treatments increased fruit flesh calcium concentration, no clear relationship could be established between fruit calcium concentration and fruit flesh firmness at harvest or after storage. Based on these data, we cannot draw any conclusion about the role of fruit calcium content on peach and nectarine quality and storage potential. A study done on the East Coast reported high fruit calcium concentrations in 'Jerseyland' peach after several foliar sprays during the growing season (4, 5). A delay of fruit softening and improvement of texture of 'Cresthaven' peach following in-season calcium spray treatments was also reported in New Jersey (5) but calcium concentrations of these fruit were not reported.

Our data indicate that in-season multiple foliar calcium sprays were not effective in increasing calcium concentration of peach and nectarine fruit. Nor were these foliar calcium sprays, applied every 14 days, starting two weeks after full bloom and continuing until one week before harvest, helpful in reducing surface discoloration incidence or in maintaining quality on the peach/nectarine cultivars studied. Work in progress by the same group (5) suggests that different calcium formulations applied at higher concentrations may improve calcium uptake without inducing phytotoxicity by peach and nectarine grown under California conditions.

Based on these work data, we can not recommend the application of these calcium formulations as a method of reducing surface discoloration disorder or maintaining peach quality.

References

1. Ceponis, M. J., R. A. Capellini, and J. M. Wells. 1987. Disorder in plum, peach, and nectarine shipments to the New York Market. Plant Dis. 71:947-952.
2. Crisosto, C. H., R. S. Johnson, and J. Luza. 1993. Incidence of physical damage on peach and nectarine skin discoloration development: Anatomical studies. J. Amer. Soc. Hort. Sci. 118(6):796-800.
3. Cheng, G. W. and C. H. Crisosto. 1994. Development of dark skin discoloration on peach and nectarine fruit in response to exogenous contaminations. J. Amer. Soc. Hort. Sci. 119(3):529-533.
4. Conway, W. S., G. M. Greene II, and K. D. Hickey. 1987. Effects of preharvest and postharvest calcium treatments of peaches on decay caused by Monilinia fructicola. Plant Disease. 71:1084-1086.
5. Johnson, R. S., C. H. Crisosto, R. Beede, H. Andris and K. Day. 1999. Foliar calcium sprays to improve peach quality. California Tree Fruit Agreement Report–1999, pp. 92.
6. Robson, M. G. 1988. Some aspects of calcium nutrition on peach growth and post harvest fruit quality. Ph.D. Thesis, Rutgers University, New Brunswick, NJ.

Journal of American Pomological Society 54(3):123-129 2000

A Crop Estimation Technique for Highbush Blueberries

JAMES F. HANCOCK,[1] PETE CALLOW,[1] REBEKAH KEESLER,[1]
DAN PRINCE[1] AND BRUCE BORDELON[2]

Abstract

This report describes our attempts to develop yield prediction methods for 'Bluecrop' and 'Jersey highbush blueberries. Considerable variability was observed across years in number of flower buds pe shoot, fruit set, individual fruit weight, cane diameter and number of laterals per cane. However, ther was a significant association between the weight of green fruit at the second stage of development an ripe fruit weight at harvest. Among five different sampling strategies, tedious counting of all the fruit i individual bushes was most tightly correlated with individual bush yields, but the quickest estimate based on counting the number of fruit within a 625 cm^2 surface (hoop counts), was also significantl associated. Hoop counts were used to estimate yields on growers fields when the bushes were at bloom the fruit were in stage II of development, and 30% of the fruit were ripe. The estimates made at the stag II and 30% ripe stages were significantly associated with actual yields, but were 15-40 % high depend ing on developmental stage and cultivar.

Introduction

Crop estimates of blueberries are currently done on a "guesstimate" basis by growers and marketing association personnel. These individuals subjectively look at the developing crop and make estimates based on their previous experience. While some individuals have an uncanny ability to estimate yield, most guesstimators do not have the experience or clarity of memory to be accurate. This has led to many inaccurate predictions of regional and national yields.

Predictions of the blueberry crop are not only limited in accuracy by the experience of the estimators, but also by seasonal variation. What may have been an accurate prediction at one stage of plant development can be radically altered by later negative environmental impacts. There are several key periods when yields are most likely to be adversely effected (4): 1) Late summer/ fall, when conditions are poor for flower bud development, 2) winter, when extreme cold damages flower buds, 3) spring, when conditions are too cool for adequate pollination or frost damages flower buds, and 4) summer, when excessive heat or drought negatively influence fruit growth.

In the early 1980s, we initiated work t estimate blueberry yields. We began b trying to determine the critical yield com ponents associated with yield (3, 6, 7). W found that number of laterals per cane, % fruit set and individual fruit weight wer extremely variable across years, and tha number of flowers per bud and buds pe lateral were more stable, but still varie significantly in some years. This variabili ty led us to believe that several yield com ponents would have to be incorporate into any yield estimation technique to ac curately predict yield. Herein, we describ how individual bushes can be sampled t accurately determine yield, and then w demonstrate that the simplest metho works on growers' fields, if corrected fo harvest losses.

Materials and Methods

Development of sampling strategies

These studies were conducted at the Va riety Trial plot of MBG Marketing i Grand Junction, MI. Seventeen cultivar were planted in 1966 in a completely ran domized design, with five, four-bush repli

[1]Department of Horticulture, Michigan State University, East Lansing, MI 48824.
[2]Department of Horticulture and Landscape Architecture, Purdue University, West Lafayette, IN 4790