Research Reports

Instrumental and Sensory Evaluation of Fruit Quality for 'Ryan's Sun' Peach Grown under Deficit Irrigation

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ADDITIONAL INDEX WORDS. **consumer panel, drought, organoleptic attributes, *Prunus persica*, trained panel, water stress**

SUMMARY. **The dwindling water supply, on a global scale, is making deficit irrigation (DI) more a necessity than a choice. It is therefore necessary to evaluate the effects of DI on fruit quality. Only instrumental evaluation of quality has been reported in the literature and, to the best of our knowledge, no sensory evaluation has been reported for any DI fruit including peach (*Prunus persica*). We applied four irrigation treatments for 50 days before harvest to 'Ryan's Sun' peach and evaluated fruit quality and sensory attributes. Treatments were: full irrigation (FI), no irrigation (NI), FI followed by NI (FI/NI), and NI followed by FI (NI/FI). NI reduced fruit size, delayed fruit maturity, and increased fruit dry matter concentration (DMC) compared with FI. NI also increased fruit soluble solids concentration (SSC) and titratable acidity (TA). A trained taste panel indicated that NI increased fruit firmness, crispness, and sourness, but it reduced sweetness, juiciness, and the intensity of peach flavor. A panel of consumers indicated reduced preference for NI fruit. Consumer preference was similar between NI/FI and FI fruit but was reduced in FI/NI fruit. There were no significant correlations between the instrumental quality parameters and sensory attributes. We conclude that NI before harvest impaired organoleptic peach quality. If only a small amount of water is available during the 50 days before harvest, peach organoleptic quality could be improved if this water is applied just before harvest.**

High quality peach fruit are produced in hot, arid regions of the world (Westwood, 1993). World water supplies are limited and there might not be enough water for agriculture by 2025 (Postel, 1998). For example, in Catalonia, Spain, where we did this research, for 5 years during the last 16 years, fruit growers were warned of impending drought with 3 years having serious water restrictions after midseason. Therefore, DI will be more of a necessity than a choice for growing peach.

Literature abounds with reports on the effects of DI on peach fruit quality as reviewed by Behboudian et al. (2011). The emphasis has been on the quality attributes measured with instruments. The results are often not conducive to firm conclusions about consumers' perception of quality. An example is the study of Lopez et al. (2010) on deficit-irrigated 'O'Henry' peach. DI significantly increased SSC and TA with no effect on the SSC/TA ratio. Based on this ratio, no conclusion could be reached on how organoleptic quality would have been affected despite the 5% increase in the SSC. As far as the sensory perception is concerned, it would also be a matter of speculation whether the higher SSC could have compensated for the measured reduction in water concentration and higher firmness of the DI fruit.

Since information on the relationships between instrumental and sensory evaluations of quality has not been reported for any deficit irrigated fruit including peach, we applied three DI treatments to 'Ryan's Sun' peach in a commercial orchard and related the instrumental evaluation of fruit quality to the sensory attributes. For the latter we used, in two sessions, a nine-member panel of trained judges and a 40-member panel of consumers. We therefore expect the information presented here to be relevant to peach producing areas of the world where water supplies are limited.

Materials and methods

EXPERIMENTAL ORCHARD AND FRUIT GROWTH STAGES. The experiment was conducted in 2010 in a commercial 'Ryan's Sun' peach orchard located in Alcarràs, Lleida, Spain (lat. 41°33′ N, long. 0°36′ E, 299 m elevation). The trees were 11 years old and were grafted onto GF-677® INRA rootstock and trained to an open vase system. They were planted 3 m apart in rows 5 m apart in a north–south orientation to 15° east

Units

To convert U.S. to SI, multiply by	U.S. unit	SI unit	To convert SI to U.S., multiply by
0.4047	acre(s)	ha	2.4711
0.1	bar	MPa	10
29.5735	fl oz	mL	0.0338
0.3048	ft	m	3.2808
3.7854	gal	L	0.2642
25.4	inch(es)	mm	0.0394
4.4482	lbf	N	0.2248
28.3495	oz	g	0.0353
7.4892	oz/gal	$g \cdot L^{-1}$	0.1335
(°F – 32) ÷ 1.8	°F	°C	(1.8 × °C) + 32

Table 1. Sensory attributes for 'Ryan's Sun' peach. Definitions and references used for each attribute and their position on the intensity scale.

Attribute	Definition	Reference standard	Intensity (150-mm scale)[z]
Sweet—taste	Characteristic of sugar	50% juice[y]	Taste 75
Acid—taste	Characteristic of acid	50% juice	Taste 80
Crispness	The amount and pitch of sound when sample is first bitten with the front teeth	Banana, celery	0 150
Firmness	The force required to compress the sample between the back teeth	Canned peach, apple	10 140
Juiciness	The amount of juice released by the sample when chewing with the back teeth	Banana, watermelon	0 150
Ease of breakdown	The amount of chewing required to break down the flesh so that it can be swallowed	Dry apricot, puree of canned peach	0 150
Fibrousness	The presence of wet and soft fibrous structures detected in the mouth during chewing	Yogurt, pineapple	0 150
Peach flavor	Characteristic peach flavor	Puree of canned peach	75

[z]1 mm = 0.0394 inch.
[y]Commercial peach juice diluted to 50% with filtered water.

of north. For the conduction of the experiment, 72 trees within 1 ha were chosen.

Two fruit per tree were sampled and weighted on a weekly basis, from fruit set to harvest, to determine fruit growth stages. Stage I was from fruit set (15 Apr.) until 1 June; Stage II was from 1 June until 20 July; Stage III was from 20 July to 27 Aug. (first harvest). Harvest was based on visual observation of fruit skin color (SC). Fruit were harvested when 70% of the skin reached a reddish color. This approach required three harvest dates (27 Aug., 3 Sept., and 8 Sept.). All fruit harvested per tree were counted and weighed at each harvest.

Irrigation treatments and experimental design. Trees were irrigated on a daily basis by drip irrigation system with six drippers per tree (2.2 $L \cdot h^{-1}$ per dripper). There was a single pipeline per tree row which passed close to the trunks of the trees. Details of tree water requirements and irrigation management are given in Lopez et al. (2008). All trees received FI from fruit set until the onset of Stage III. The irrigation treatments were applied only during Stage III. They were: 1) FI, 2) NI, 3) FI at the beginning of Stage III for 17 d followed by NI of 33 d (FI/NI), and 4) NI at the beginning of Stage III for 34 d followed by FI of 16 d (NI/FI).

A randomized complete block design with three block replicates was used. Each block housed the four treatments in four different plots. Each plot had four rows of five trees. The six central trees of the two middle rows were used as experimental trees and all the others as guard trees.

Measurements of applied water and tree water status. The amount of water applied to each plot was measured with digital water volume meters (CZ2000–3M; Contazara, Zaragoza, Spain). Midday stem water potential (SWP) was measured 2 d per week during the fruit growing season. This was done with a pressure chamber (model 3005; Soil Moisture Equipment Corp., Santa Barbara, CA). Measurements were taken at solar noon ± 30 min from leaves located near the bases of the trees (one leaf per tree) using the procedure outlined by McCutchan and Shackel (1992). For the FI treatment, three experimental trees per plot were monitored during the whole fruit growing season. For the DI treatments (NI, FI/NI, and NI/FI), three experimental trees per plot were monitored before the application of DI. Once DI started, we monitored all the experimental trees per plot.

Instrumental determination of fruit quality. We determined the following fruit quality attributes: (DMC), SC, flesh firmness (FF), juice SSC, and juice TA. DMC (%) was determined during the whole season by taking samples of 12 fruit per plot (two fruit per experimental tree) every 2 weeks. DMC of each sample was calculated as: DMC = (dry weight/fresh weight) × 100. The dry weight of each sample was obtained after drying to a constant weight in a forced-air draft oven at 65 °C. SC (hue°), FF (N), SSC (percent), and TA (grams malic acid per liter) were determined four times (20 July, 6 Aug., 23 Aug., and 3 Sept.) by taking samples of 18 fruit per plot (three fruit per experimental tree). SC and FF from two opposite fruit cheeks (most exposed and least exposed to light) were determined for each fruit using a photoelectric tristimulus colorimeter (CR-200; Minolta, Osaka, Japan) and a manual penetrometer with an 8-mm tip fixed in a drill stand (Penefel; Copa-Technology, CTIFL, Saint Etienne du Gres, France), respectively. SSC and TA were determined from the mixture of juice obtained from the fruit sampled per elemental plot. SSC was determined using a digital calibrated refractometer (PR-32α Palette Series; Atago, Tokyo). TA was determined by titrating with 0.1 N sodium hydroxide (NaOH) to a pH endpoint of 8.2.

Sensory evaluation. The sensory evaluation involved two panels: a panel of consumers and a panel of

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trained judges. The panel of consumers consisted of ≈40 experienced volunteers from the staff working at the Institut de Recerca i Tecnologia Agroalimentàries. All of them were regular consumers of peach. The trained panel comprised nine judges trained according to the procedures determined by the International Organization for Standardization [no. 8586–1 (ISO 1993)]. The training process included 15 sessions of 90 min each. Training sessions were conducted to instruct the judges on measuring the perception of the following attributes: sweetness, sourness, flavor intensity, juiciness, firmness, crispness, ease of breakdown, and fibrousness. Terms of references used to ensure panel consistency are presented in Table 1.

Both panels were provided with fruit samples taken from each treatment (36 fruit per treatment). These samples were taken at the same time as the last two sampling dates for instrumental fruit quality determination (23 Aug. and 3 Sept.). To evaluate sensory quality as perceived by the consumer, fruit were stored for 1 week at 0 °C and 90% relative humidity. After cold storage, fruits were kept in a room at 20 °C for 1 d. Sensory evaluation was therefore done by the panel of consumers and the trained panel in two sessions.

For the panel of consumers, each fruit was divided into four pieces and was evaluated separately by four consumers. The quarterfruit (without skin) were placed on a white plate and immediately presented to a consumer. Each plate was therefore presented with four quarterfruit (a quarterfruit for each treatment). Samples were identified using three digits, and the samples were presented to each consumer in a randomized order. The consumers assessed all the samples and were asked to rate overall fruit acceptability according to a hedonic test (1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much, and 9 = like extremely). Consumer acceptance was expressed as the average degree of liking (1–9) and in three acceptance categories using the procedures outlined by Crisosto and Crisosto (2005): acceptance (percentage of consumers with score higher than 5), neither like nor dislike (percentage of consumers with score equal to 5), and dislike (percentage of consumers with score lower than 5).

For the panel of trained judges, a sample for taste consisted of three fruit pieces of 1.5 cm^3 (without skin). Samples were presented in random order in 100-mL beakers labeled with three-digit random numbers. The intensity of each sensory attribute (Table 1) was recorded on 150-mm unstructured line scales, anchored at 0 = absent and 150 = extreme, with

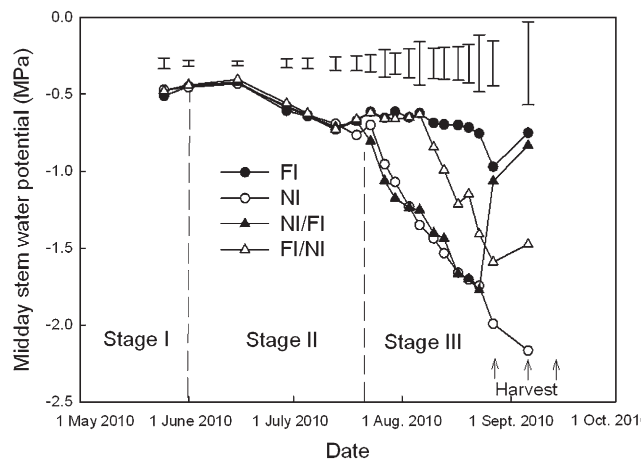

Fig. 1. Seasonal patterns of midday stem water potential for 'Ryan's Sun' peach. Separate bars are the least square difference at $P < 0.05$. Arrows indicate the dates of harvest. FI = full irrigation, NI = no irrigation, FI/NI = FI followed by NI, and NI/FI = NI followed by FI; 1 MPa = 10 bar.

Table 2. Effects of irrigation treatments on 'Ryan's Sun' peach yield components.

Treatment[z]	Crop load (fruit/tree)	Fruit wt (g)[y]	Fruit at each harvest (%) First (27 Aug.)	Second (3 Sept.)	Third (8 Sept.)
FI	344 a[x]	172 a	55 a	44 a	1 b
NI	408 a	117 c	19 b	55 a	26 a
FI/NI	419 a	142 b	48 a	46 a	6 b
NI/FI	384 a	136 b	14 b	47 a	38 a

[z]FI = full irrigation, NI = no irrigation, FI/NI = FI followed by NI, and NI/FI = NI followed by FI.
[y]1 g = 0.0353 oz.
[x]Means followed by different letters in the same column are significantly different at 5% according to least square difference test.

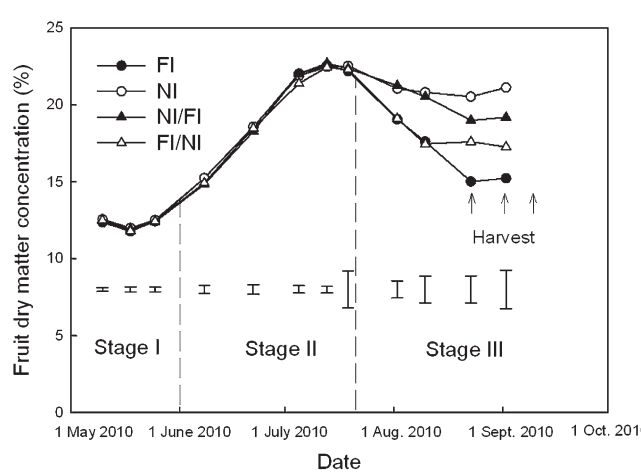

Fig. 2. Seasonal patterns of fruit dry matter concentration for 'Ryan's Sun' peach. Separate bars are the least square differences at $P < 0.05$. Arrows indicate the dates of harvest.FI = full irrigation, NI = no irrigation, FI/NI = FI followed by NI, and NI/FI = NI followed by FI.

the exception of firmness, which was anchored at 10 = low and 140 = high. Consumer and judges cleansed their palates between samples with mineral water and crackers.

Data analysis. Treatment effects on tree water status, crop load, average fruit weight at harvest, percentage of fruit harvested at each harvest date, quality attributes, degree of liking, and sensory attributes were evaluated by analysis of variance. Principal component analysis (PCA) was used to quantify the correlation between instrumental quality measurements, sensory attributes, and consumer acceptance. Analyses were performed using SAS (enterprise guide 4.2; SAS Institute, Cary, NC). Statistical significance was established for $P < 0.05$. Pearson's correlation was used to evaluate the dependence of two variables. Least square difference tests were applied to separate least square means that differed significantly.

Results

Applied water, tree water status, and yield components. Total rain from fruit set until harvest was 72 mm. Rain at Stage III was 3 mm. The total amounts of water applied during Stage III were 230, 116, and 90 mm for FI, FI/NI, and NI/FI, respectively. NI trees received NI.

FI maintained SWP values at around –0.70 MPa during Stage III (Fig. 1). NI and NI/FI trees had similar and a significantly lower SWP than FI trees until NI/FI trees were reirrigated. When NI/FI trees were fully irrigated for 17 d before harvest, their water status was fully recovered by harvest (Fig. 1). For NI trees, SWP values decreased to a value of –2.1 MPa. FI/NI trees reached minimum values of –1.5 MPa at harvest (Fig. 1). During Stage III, average values of SWP were –0.70, –1.01, –1.27, and –1.50 MPa for FI, FI/NI, NI/FI, and NI, respectively.

Crop load was similar among treatments, but more fruit were harvested during the first pick in FI and FI/NI trees (Table 2). In the third pick, a high number of fruit was still harvested in NI and NI/FI trees, while almost no fruit were harvested in FI and FI/NI trees. Average weight was lower in NI/FI and FI/NI fruit than in FI fruit. NI fruit had the lowest average weight (Table 2).

Instrumental fruit quality. During Stage III, DMC in NI fruit was higher than in FI fruit (Fig. 2). NI/FI and FI/NI fruit had DMC values between FI and NI fruit. In NI/FI and FI/NI fruit, DMC did not decrease when they were not irrigated. FF was similar among treatments at harvest (Fig. 3A). However, 17 and 34 d after the onset of Stage III, NI and NI/FI fruit were firmer than FI fruit. FI/NI fruit had FF values between FI and the other treatments. Thirty-four days after the onset of Stage III, SC in NI and NI/FI fruit had higher hue° values than FI and FI/NI fruit in the shaded part of the fruit (Fig. 3C), indicating less intensity of red color. These differences were reduced at harvest, and only hue° values from

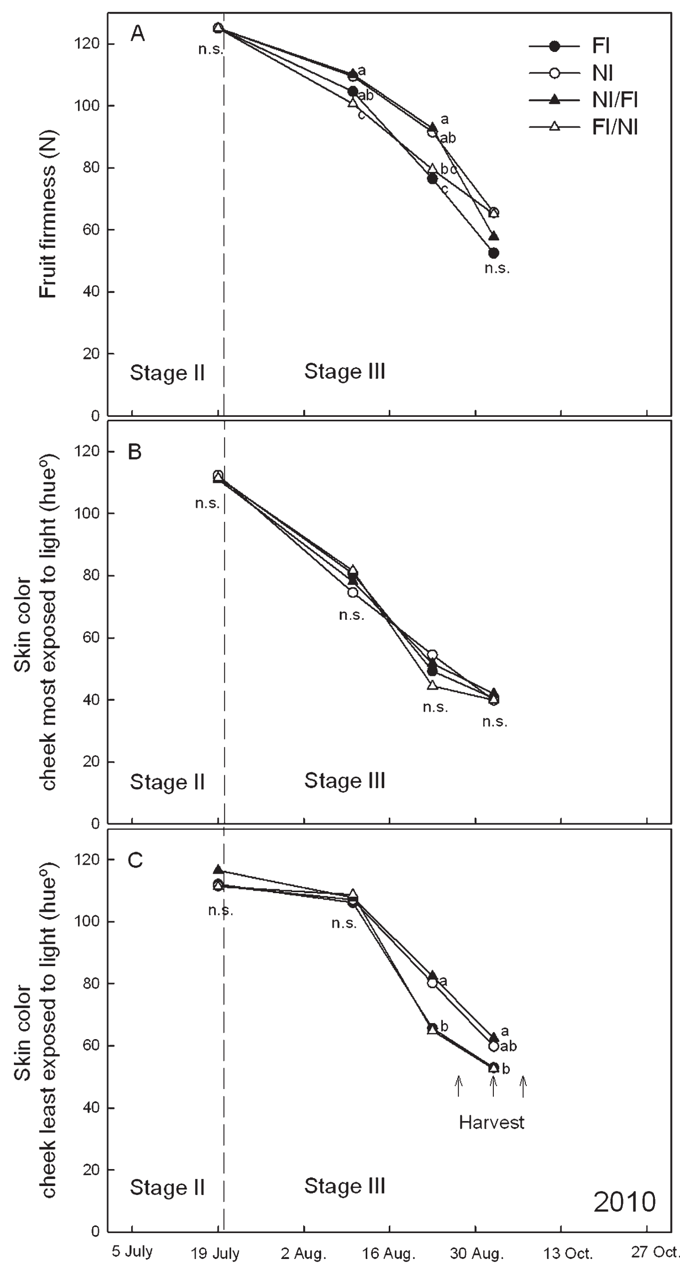

Fig. 3. Patterns of fruit firmness (A) and skin color in the cheek most exposed (B) and least exposed (C) to light during Stage III for 'Ryan's Sun' peach. Means followed by different letters for the same day of evaluation are significantly different at 5% according to least square difference test (n.s. denotes no significant difference). Arrows indicate the dates of harvest. Higher hue° values indicate less red color. FI = full irrigation, NI = no irrigation, FI/NI = FI followed by NI, and NI/FI = NI followed by FI; 1 N = 0.2248 lbf.

NI/FI fruit were higher than in FI and FI/NI fruit. SSC in NI and NI/FI fruit was higher than in FI/NI and FI fruit during Stage III (Fig. 4A). NI and NI/FI fruit had higher TA values than FI fruit at harvest (Fig. 4B). FI/NI had TA values between FI and the other treatments. Treatments had no effect on the SSC/TA ratio (Fig. 4C).

SENSORY EVALUATION. Consumer sensory evaluations were performed in two sessions. By the first session, NI/FI trees had not received any irrigation, and this treatment can therefore be considered a replicate of the NI treatment at this stage. For this reason, full comparison of consumer acceptance between treatments can only be established in the second session. Acceptance of peach fruit by consumers in response to irrigation treatments is presented in Table 3. Consumer acceptance (score > 5) in the second session for FI, NI, NI/FI, and FI/NI fruit was 78%, 51%, 63%, and 54%, respectively. Statistically FI and NI/FI fruit had similar degrees of liking in the second session (Table 3). FI/NI and NI had lower degrees of liking than FI fruit (Table 3).

The treatments caused significant differences in all the sensory attributes evaluated by the trained panel of judges except in fruit fibrousness (Table 4). During the second session, NI had higher fruit firmness and crispness and lower sweetness, juiciness, and intensity of peach flavor in comparison with FI (Table 4). NI fruit had higher sourness than FI in the first session. In the second session, sensory traits were similar between FI/NI and NI/FI fruit with exception of fruit crispness (Table 4). In the first session, FI/NI fruit were less sweet, more sour, less juicy, and more firm than FI fruit. Similar differences were observed between NI/FI and FI fruit although the differences in sweetness were not significant (Table 4). In the second session, NI/FI and FI/NI fruit were less firm and presented higher values of ease to breakdown than FI fruit (Table 4).

RELATIONSHIPS BETWEEN INSTRUMENTAL FRUIT QUALITY, SENSORY ATTRIBUTES, AND CONSUMER ACCEPTANCE. Instrumental fruit quality was not significantly correlated with sensory attributes (results not shown). There were significant correlations among some sensory attributes determined by the trained panel of judges (Table 5). Sourness and fibrousness were not correlated with any other sensory attributes (results not shown). When PCA models were developed to quantify the correlation between sensory attributes and consumer acceptance, the best PCA model was obtained using consumer dislike data (Fig. 5). Principal components 1 and 2 accounted for 68.24% and 14.82% of total variance, respectively. The highest correlation was observed between sourness and consumer dislike degree (Fig. 5).

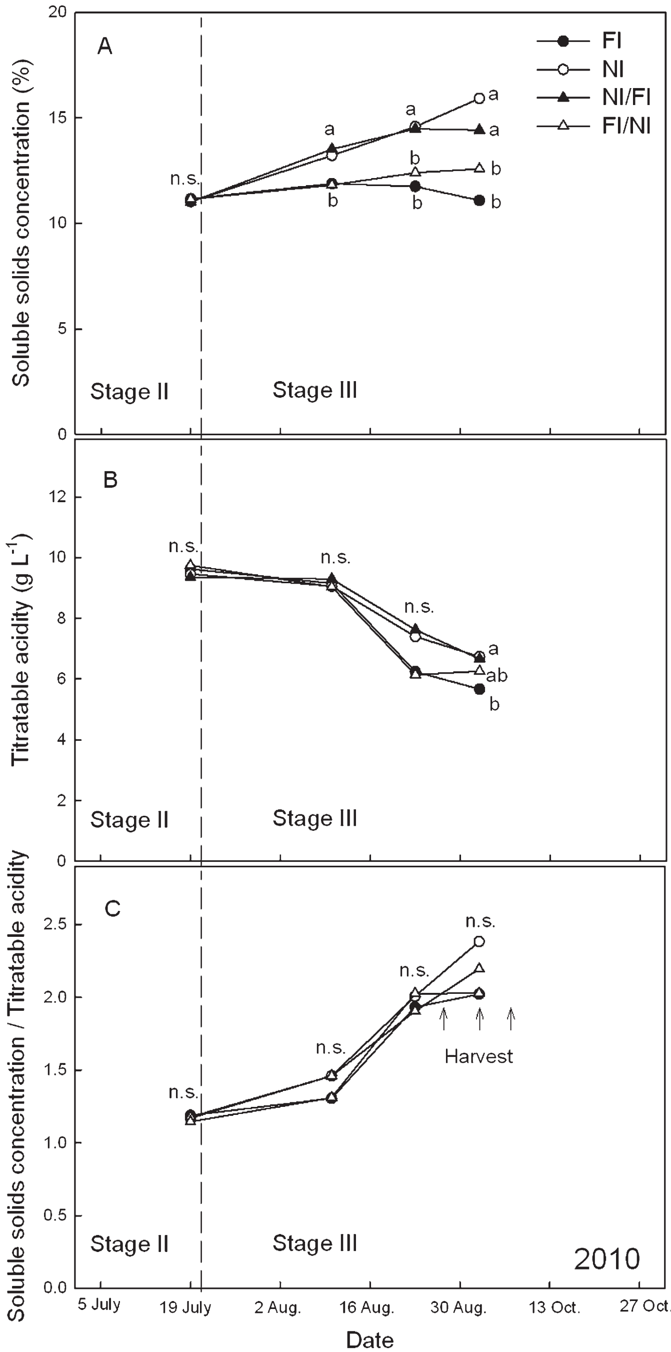

Fig. 4. Patterns of soluble solids concentration (A), titratable acidity (B) and soluble solids concentration/acidity ratio (C) during Stage III for 'Ryan's Sun' peach. Means followed by different letters for the same day of evaluation are significantly different at 5% according to least square difference test (n.s. denotes no significant difference). Arrows indicate the dates of harvest. FI = full irrigation, NI = no irrigation, FI/NI = FI followed by NI, and NI/FI = NI followed by FI; 1 g·L^{-1} = 0.1336 oz/gal.

Discussion

In this study, we evaluated fruit quality of peach subjected to water stress using instrumental and sensory analyses. The values of SWP measured in the DI treatments (Fig. 1) are indicative of severe water stress. NI for 50 d before harvest reduced fruit size and delayed maturity compared with FI (Table 2). NI fruit had higher FF, SSC, TA, and DMC, but red fruit color was less intense in the shaded part of the fruit (Figs. 2–4). Reductions in fruit size in response to severe water stress before harvest are consistent with Berman and DeJong (1996) and Lopez et al. (2006). For peach fruit from nonirrigated trees, delays in maturation have been reported by Lopez et al. (2010) and Proebsting and Middleton (1980), while enhancements in FF, SSC, TA, and DMC have been observed by Lopez et al. (2010). Our results indicate for the first time a reduction in consumer liking degree and consumer acceptance in NI fruit (Table 3). This could be explained by the effect of NI on sensory traits. NI fruit had higher firmness, crispness, and sourness but lower sweetness, juiciness, and intensity of peach flavor (Table 4). Principal components analysis indicated that sourness was the sensory parameter that had a greater influence on peach consumer acceptance and its influence was negative (Fig. 5). Effects of NI on sensory traits could partially be related to water stress. NI could also have affected fruit maturity. The seasonal patterns of fruit quality shown in Fig. 3 could facilitate the distinction of these two effects. Assuming that FF and SC are good indicators of fruit maturity in peach (Crisosto, 1994), it could be possible to compare sensory traits of NI and FI fruit for a given maturity level. For example, FI fruit sampled on 23 Aug. had similar FF and SC as NI fruit sampled on 3 Sept. However, the consumer liking degree and sensory attributes were impaired in NI fruit (Tables 3 and 4). We therefore suggest that NI reduced fruit organoleptic quality regardless of its maturity. The other DI treatments also reduced consumer acceptance, but we observed similar consumer liking degree values between FI and NI/FI fruit (Session 2 in Table 2). This required applying 25% of peach water requirements just before harvest. Applying 60% of peach water requirements early during Stage III (FI/NI treatment) reduced consumer liking degree in comparison with FI (Session 2 in Table 2). Since NI/FI fruit had better consumer acceptance and consumer liking degree than FI/NI fruit with a lower amount of water, organoleptic fruit quality appeared to be favored if water is applied just before harvest.

Instrumental quality and sensory attributes had poor correlations (results not shown). However, comparing instrumental and sensory analyses could explain the reason why the trained panel of judges detected fruit with higher firmness, crispness, and sourness and lower sweetness, juiciness, ease of breakdown, and flavor intensity in NI fruit (Table 4). Low juiciness and high sourness in NI fruit could be expected because NI fruit had high DMC and TA (Table 4; Figs. 2 and 3B). Higher firmness in

Table 3. Effects of irrigation treatments on 'Ryan's Sun' peach acceptance. There were 42 consumers in the first session and 55 in the second.

	Session 1 (Fruit sampled in 23 Aug.)				Session 2 (Fruit sampled in 3 Sept.)			
	Treatment[z]							
Irrigation (mm)[y]	FI 161	NI 0	NI/FI 0	FI/NI 116	FI 199	NI 0	NI/FI 49	FI/NI 116
Acceptance (%)	73	50	54	59	78	51	63	54
Neither like nor dislike (%)	12	19	12	14	9	16	22	25
Dislike (%)	15	31	33	26	13	32	16	22
Degree of liking (1–9 scale)[x]	6.42 a	5.45 b	5.45 b	5.83 ab	6.52 a	5.56 b	6.00 ab	5.82 b

[z]FI = full irrigation, NI = no irrigation, FI/NI = FI followed by NI, and NI/FI = NI followed by FI.
[y]1 mm = 0.0394 inch.
[x]1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much, and 9 = like extremely. Means followed by different letters in the same session are significantly different at 5% according to least square difference test.

Table 4. Effects of irrigation treatments on 'Ryan's Sun' peach sensory attributes. Sensory evaluation was assessed in two sessions according to the references presented in Table 1.

Treatment code (irrigation in mm)[z]	Sweetness	Sourness	Flavor intensity	Juiciness	Firmness	Crispness	Ease of breakdown	Fibrousness
Session 1 (fruit sampled on 23 Aug.)								
FI (161)	8.5 a[y]	3.8 b	7.0 a	7.2 a	7.1 b	6.5 ab	7.8 a	1.6 a
NI (0)	7.6 ab	6.7 a	6.6 a	5.6 ab	7.4 ab	5.1 b	7.6 a	2.0 a
FI/NI (116)	6.5 b	6.1 a	5.0 a	3.3 c	9.2 a	6.8 ab	6.1 a	1.6 a
NI/FI (0)	6.8 ab	6.3 a	6.8 a	4.7 bc	9.2 a	8.2 a	7.3 a	2.0 a
Session 2 (fruit sampled on 3 Sept.)								
FI (199)	7.3 a	5.4 a	6.7 a	6.5 a	8.4 b	6.3 b	7.0 b	2.0 a
NI (0)	5.4 b	6.1 a	3.7 b	3.5 b	10.6 a	9.1 a	5.8 b	1.1 a
FI/NI (116)	8.0 a	5.2 a	7.8 a	7.6 a	5.7 c	2.7 c	9.2 a	1.3 a
NI/FI (49)	8.5 a	6.1 a	8.1 a	7.8 a	6.3 c	4.7 b	9.2 a	2.1 a

[z]FI = full irrigation, NI = no irrigation, FI/NI = FI followed by NI, and NI/FI = NI followed by FI. Values in parentheses following treatment codes represent irrigation applied from the onset of Stage III until the date of fruit sampling; 1 mm = 0.0394 inch.
[y]For a given session, means followed by different letters in the same column are significantly different at 5% according to least square difference test.

Table 5. Pearson correlation coefficients (r) among sensory attributes of 'Ryan's Sun' peach determined by the trained panel of judges.

Sensory attributes	Sweetness	Firmness	Juiciness	Crispness	Ease of breakdown	Flavor intensity
Sweetness	1.00	–0.91	0.88	–0.71	0.85	0.88
Firmness		1.00	–0.91	0.91	–0.93	–0.89
Juiciness			1.00	–0.76	0.90	0.90
Crispness				1.00	–0.81	–0.74
Ease of breakdown					1.00	0.93
Flavor intensity						1.00

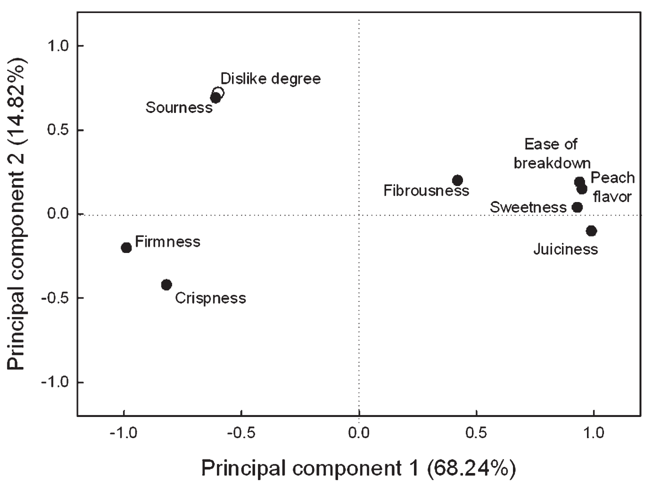

Fig. 5. Effect of sensory attributes on consumer dislike degree by principal components analysis for 'Ryan's Sun' peach.

NI fruit might be explained by their lower size (Tables 2 and 4). Smaller fruit tend to be firmer than larger fruit because of a higher cellular density (Behboudian et al., 2011). This may also be the reason why NI fruit had higher crispness and lower ease of breakdown values (Table 4). These parameters were significantly correlated with firmness (Table 5). NI fruit were sensed as less sweet than FI fruit despite the increase of ≈5% in SSC (Fig. 4A, Table 4). Byrne et al. (1991) stated that SSC is not necessarily related with sweetness because SSC values obtained using a refractometer reflect the presence of all optically active soluble compounds such as acids, salts, pectins, and sugars. Acidity and salts have been reported to increase with NI before harvest because of fruit dehydration (Lopez et al., 2010). Two other reasons may explain lower sweetness with high SSC. The first reason is the positive relationship between peach juiciness and sweetness observed in our study (Table 5) and by Infante et al. (2009, 2011). Since NI decreased juiciness, a low amount of sugars dissolved in the juice may have been available in the panelists' mouth, and thus sensed that NI fruit had low sweetness. The second reason is the interaction between sweetness and sourness. Acidity could modulate the perception of peach sweetness (Esti et al., 1997; Ortiz et al., 2008), and high acidity masks the perception of sweetness (Iglesias and Echeverria, 2009). Colaric et al. (2005) determined that peaches with low sweetness had high acid contents. Since NI had higher acidity, NI might have distorted the expected positive relationships between SSC and sweetness as reported in Crisosto et al. (2006). SSC/acidity ratio would be therefore a potential indicator of sweetness (Crisosto et al., 2006; Di Miceli et al., 2010), but in our study, there were no significant relationships between sweetness and SSC/TA ratio (results not shown). It is difficult to explain the low peach flavor intensity in NI fruit (Table 4). Although the intensity of flavor was correlated with sweetness, firmness, and juiciness, the perception of peach flavor has been related to the emission of aroma volatiles (Ortiz et al., 2008). But it is not known how peach aroma volatiles are affected by water stress.

Conclusions

Using instrumental analysis such as measurements of SSC or the SSC/TA ratio to assess peach organoleptic quality and consumer acceptance in response to DI is not recommended when other important quality attributes such as fruit firmness and fruit water concentration are altered by water stress. The use of sensory evaluation techniques in DI studies could help gain a better understanding of the effect of different levels of water stress on fruit organoleptic quality. Severe levels of water stress before harvest reduced peach organoleptic quality and consumer liking degree. In years with limited water allocations late in the season, applying the available water just before harvest may produce better results in terms of organoleptic quality. This would be preferable to applying the water at the onset of Stage III and stressing the tree at the end of this period.

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