Investigation note

Characterization of peach genotype fruits as an alternative to expand the fresh marketing offer

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Abstract

Zacatecas peach production currently faces low productivity and competitiveness due to multiple factors. Therefore, the objective of the study was to characterize peach genotypes with outstanding characteristics at harvest time and fruit quality. A group of 91 six-year-old genotypes from an improved population of 403 hybrids and peach segregates, planted at random at high densities in 2008, was selected and evaluated in 2014. Controls were 'Victoria' and a segregator from 'Victoria' (VicS). For the phenotyping of the fruit (*n*= 10), it was harvested at consumption maturity. The response variables of each fruit were: polar and equatorial diameter, fresh mass, endocarp and mesocarp mass, and dry matter concentration of each fruit; as well as the color of the epicarp and mesocarp, firmness and concentration of total soluble solids. The outstanding peach genotypes GD1, GD3, GD5, and GD7 matured in June, GD43 in July, GD45, GD47, and GD68 in August, while GD70, GD77, and GD87 matured in September, respectively. In addition, these genotypes had the best phenotypic characteristics of the fruit. The results suggest that the fresh fruit supply period and the diversification of peaches with competitive quality for Zacatecas and similar agroecological zones can be extended to improve the prospects for cultivation in these regions.

Keywords: *Prunus persica* (L.) Batsch, harvest time, phenotyping by fruit quality.

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In Zacatecas, 7 356 ha are currently cultivated with peaches, of which 9.8% are under irrigation and the rest is cultivated in temporary crops with yields of 6.8 t ha^{-1} and 3.1 t ha^{-1}, respectively (SIAP, 2019), being one of the most important fruit species in the state. Due to tradition and lack of varieties adapted to the agroecological conditions of the various producing areas of the state, most orchards have been established with sexually propagated creole peaches. The latter has generated a rich genetic heterogeneity between and within orchards that has been exploited for the selection of outstanding genotypes in adaptation and productivity (Zegbe-Domínguez *et al*., 1999).

However, most of the genotypes show an early flowering and, therefore, recurrent damage due to late frosts is observed during flowering and fruit settling. The latter led to the successful search for late-flowering genotypes (Zegbe-Domínguez and Rumayor-Rodríguez, 1994). However, the seasonality of production significantly affects the competitiveness of this product, because an oversupply of the fruit is generated during August and September, which negatively impacts sales prices (Sánchez-Toledano *et al*., 2019).

At the same time, the presence of harmful microorganisms such as powdery mildew (*Podosphaera pannosa*) during the driest months (Pascal *et al*., 2010) and fruit rot caused by *Monilinia fructicola* during the rainy season, in addition to increasing costs of production, reduce the quality and postharvest life of the fruit (Yanez-Mendizabal *et al*., 2012). The objective of this study was to characterize peach genotypes with outstanding characteristics in terms of harvest times and fruit quality for the producing areas of the state of Zacatecas.

This research is conducted at the Zacatecas Experimental Field (22º 54’ north latitude and 102º 39’ west longitude, at 2 197 masl) of the National Institute of Forestry, Agricultural and Livestock Research (INIFAP). The site’s climate is semi-arid, with an average annual rainfall of 416 mm, where 75% of this occurs in the months of June to September. The average annual temperature is 14.6 ºC and the average annual cold accumulation from November to February is 600 cold units. The soil is of the clay loam type. The study was carried out in a genetic improvement population planted in high densities (2.5 m × 4.5 m between tree and rows, respectively) in August 2008.

This segregating population (n = 403) came from 40 families of self-fertilized F_2 progeny and crosses, where the variety ‘Victoria’ and the selection ‘S66’ were used as females (♀). From this population arranged at random, 89 outstanding genotypes were selected and the variety ‘Victoria’ and a segregating of ‘Victoria’ called ‘VicS’ were included as controls. Likewise, the occurrence of anthesis was recorded, it was considered complete when each genotype reached 90% of this phenological stage, the date on which the fruit showed the proper color of consumption maturity of each genotype was also recorded (eg, yellow, yellow plated, etc.).

The physical-chemical phenotyping of the fruit was based on a sample of 10 fruits per genotype. The fruit was collected at random, from the middle part and around the trees, it was tried that it was uniform in size, color, health and in consumption maturity. In each fruit the dimension of the polar and equatorial diameters was evaluated with a digital vernier (Model CD-6, CS, Mutituyo Co., Japan). In an analytical balance (Velab Model-VE-303, Class II) the individual mass of each fresh fruit was measured. The color of the exocarp (epidermis) and mesocarp of each fruit was determined at two opposite sites in the equatorial zone with a spectrophotometer (X-rite Model-SP64, Canada).

Subsequently, with a penetrometer equipped with an 11.1 mm diameter punch (model FT 327, Wagner Instruments, Greenwich, CT, USA) firmness was determined in two opposite sites of the middle part of each fruit. A few drops of juice were taken and mixed to quantify the concentration of total soluble solids with a digital refractometer (Model PR-32α, Atago, Co. ltd., Tokyo, Japan). Each fruit was separated into mesocarp and endocarp to determine the fresh mass of both structures. The dry matter concentration was determined with a sample of 25 g of fresh mesocarp (including the epidermis) per fruit and it was brought to constant dry weight in an oven for eight days at 60 °C. The information was analyzed multivariate by principal components with the statistical analysis system (SAS Institute v. 9.3, 2002-2010, Cary, NC, USA).

Based on one of the objectives, within the studied population, 16, 29, 24 and 22 genotypes were identified whose maturation occurred in the months of June, July, August and September, respectively (Table 1). The genotypes that matured in June (16 selections) and July (29 selections), potentially open a window of low supply of peaches in the domestic market. With the identification and cultivation of these 45 genotypes, in theory, the seasonality of the supply of the Zacatecan peach would be ended or reduced and therefore, it would contribute to increase its competitiveness in the national market (Sánchez-Toledano *et al.*, 2019) considering the Mexican standard for fresh peach (NMX-FF-060-SCFI-2009).

However, as a fundamental part of the genetic improvement of peach (Zegbe-Domínguez *et al.*, 1999), it was observed that some quality attributes tended to increase from June to August, to later decrease during September (Table 1). This was clearly noted in the dimensions of the fruit, which suggests that, in genotypes with a fruit development period between 90 and 100 days, the availability of carbohydrates was not enough to export it to the fruit (Genard *et al.*, 2003). Consequently, the genotypes with early ripening fruit had, on average, the smallest fruit dimensions, less concentration of dry matter, firmness and total soluble solids concentration than those that ripened in August and September (Table 1). However, that the early ripening fruit presented some deficiencies in size, it maintained the organoleptic characteristics that identify the Zacatecan peach.

Table 1. Fruit attributes (± standard deviation; *n*= 10 fruits) of 91 peach genotypes analyzed in the 2014 crop cycle. The value in parentheses indicates the number of segregators that made up each average.

Response variables	Harvest time			
	June (16)	July (29)	August (24)	September (22)
Polar diameter (mm)	45.9 ±5.7	56 ±6.7	55.8 ± 4.1	54.9 ±4.1
Equatorial diameter (mm)	46.8 ±6.2	57.3 ±6.4	58.1 ± 4.1	56.7 ±3.3
Fresh fruit mass (g)	56.2 ±20.7	97.7 ±30.1	100.7 ±18.3	93.2 ±14.5
Mesocarp mass(g)	52.3 ±20.2	92.8 ±28.9	95 ±17.9	88.1 ±14.3
Fruit dry matter concentration (mg g^{-1} MFF*)	123.3 ±23.7	165.4 ±24.8	165.2 ±19.9	175.1 ±18.4
Firmness (Newtons)	5.6 ±1.9	6.7 ±2.1	7.8 ±1.6	7.4 ±2.9
Total soluble solids concentration (%)	14 ±1.5	13.5 ±1.5	15.3 ±1.4	15.4 ±1.5

MFF= is the mass of the fresh fruit.

The multivariate analysis by principal components revealed that collectively the physical-chemical variables of the fruit of the 91 genotypes show particular relevance in the first three principal components (CP) and together they explain 72.3% of the variability (Table 2).

Table 2. Root vector (Vr) and simple correlation (r) between original values [mean ($\bar{X}$) ± standard deviation (SD)] of physical-chemical attributes of the fruit and the first three main components of peach genotypes.

Response variables	$\bar{X}$ ±SD	Main components (CP)					
		I		II		III	
		Vr	r	Vr	r	Vr	r
Polar diameter (DP)	54.3 ±5.7 (mm)	0.42	0.93	-0.18	-0.26	-0.06	-0.07
Equatorial diameter (DE)	55.9 ±6 (mm)	0.43	0.95	-0.18	-0.25	0.02	0.03
DE/DP ratio	1 ±0.1	0.03	0.57	-0.14	-0.2	0.37	0.4
Fresh fruit mass	92.3 ±25.2 (g)	0.44	0.96	-0.18	-0.26	0.02	0.02
Endocarp mass	5.1 ±1.2 (g)	0.37	0.8	0.08	0.12	0.08	0.09
Mesocarp mass	87.1 ±24.3 (g)	0.43	0.95	-0.19	-0.27	0.02	0.02
Concentration of the dry matter of the fruit	167.5 ±17.8 (m g^{-1} MFF)	0.02	0.05	0.122	0.17	0.82	0.88
Epidermis color	72.5 ±8.7 (ºHue)	0.26	0.57	0.421	0.59	-0.16	-0.17
Mesocarp color	75 ±6.3 (ºHue)	0.12	0.26	0.495	0.7	-0.11	-0.11
Firmness	68.6 ±16.9 (N)	0.17	0.38	0.385	0.54	-0.21	-0.23
Total soluble solids concentration	14.6 ±1.5 (%)	0.11	0.24	0.5	0.7	0.29	0.31
Root value		4.8		2		1.1	
Explained variance (%)		43.8		18.1		10.4	

CP I= represents ‘dimensions of the fruit’; CP II= represents ‘sweetness, firmness and epidermis color’; CP III= represents ‘the concentration of dry matter of the fruit’.

The first component (CPI) absorbed the greatest variability (43.8%). This CP was called ‘fruit dimensions’ because it was associated with the polar diameter, equatorial diameter, fresh fruit mass (MFF), endocarp mass (ME) and mesocarp (MM). The second CP explained 18.1% of the total variability and was associated with the color of the epidermis (CE), color of the mesocarp (CM), fruit firmness (FF) and the concentration of total soluble solids (CSST), therefore, it was referred to as ‘sweetness, firmness and epidermis color’. The third CP explained 10.4% of the variability, which was attributed only to the concentration of dry matter of the fruit (CMSF).

Among the peach genotypes (GD) that matured in the month of June, considering the first three CP, the genotypes of importance were: GD1, GD3, GD5 and GD7. This last genotype was selected for producing relatively large fruit, but unfortunately it showed, on average, low values in CMSF, CSST, FF and reddish epidermis (Figure 1, quadrant II), characteristics opposite to the first three genotypes (Figure 1, quadrant IV).

The GD43 genotype matured in July and produced large fruit with CMSF above average, reddish epidermis color, but CSST and FF were below average (Figure 1, quadrant II). Genotypes GD45, GD47, and GD68 matured in August. The first two produced large fruits with CMSF above average, with reddish color on the epidermis, but CSST and FF were below average (Figure 1, quadrant II). The GD68 genotype produced smaller fruit than the first two genotypes, but with high CSST, FF, CMSF and with yellow epidermis (Figure 1, Quadrant I).

In the September ripening, the GD70, GD77 and GD87 genotypes stood out, where GD77 produced fruit with high CSST, FF, yellow color of the epidermis and CMSF, but the fruit dimensions were smaller than the average (Figure 1, quadrant IV). In contrast, the GD70 and GD87 genotypes produced fruit of similar dimensions to the controls (‘Victoria’ and ‘VicS’), but with higher CSST, FF, CMSF and yellow epidermis color (Figure 1, quadrant I). ‘VicS’ and ‘Victoria’ were located with average fruit characteristics to the Zacatecan creole. However, ‘Victoria’ recorded the lowest CMSF values than the rest of the genotypes included in this study (Figure 1, quadrant I).

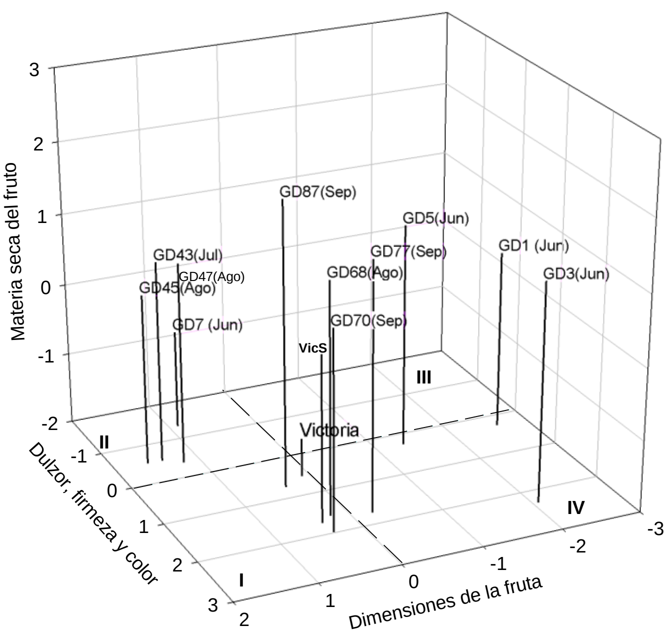

Figure 1. Three-dimensional position of peach genotypes (GD) with maturation in June (Jun), July (Jul), August (Aug) and September (Sep). Based on the values of the components associated with the dimensions (main component I), some physical-chemical attributes (main component II) and dry matter of the fruit (main component III). ‘VicS’ is the segregator of the cultivar ‘Victoria’.

After seven years of conducting this peach improvement population composed of F_2 segregants and hybrids of the variety ‘Victoria’ (♀), the desired variability was found to widen the supply window of peach with different physical-chemical characteristics of the fruit (Rodríguez-A *et al*., 1986). Even though the genotypes that ripened in June did not have the desired fruit dimensions in the fresh market (NMX-FF-060-SCFI-2009), except for GD7, the physical-chemical characteristics of its fruit are an economically important attraction. in a time of null supply of this fresh product (Sánchez-Toledano *et al*., 2019).

As in other fruit crops, such as the same peach (Rodríguez-A *et al*., 1986), cherry (Iezzoni and Pritts, 1991) or apple tree (Posadas-Herrera *et al*., 2018), the genotypes positioned in Quadrant I (Figure 1) suggest a clear advance in genetic improvement in the fruit dimensions, FF, CE, CSST and CMSF in relation to the controls 'Victoria' and 'VicS' (Figure 1). Therefore, since genetic improvement is dynamic and necessarily has to be useful, all those genotypes that are positioned in the lower left part of quadrant I (Figure 1), will suggest significant genetic improvement and economic importance for the peach producer.

Conclusions

The phenotyping of the peach genotypes by quality attributes allowed to find outstanding individuals whose fruit ripens in June and July, consequently, this opens the possibility of expanding the fresh marketing window. The physicochemical characteristics of the fruit of the GD70, GD77 and GD87 genotypes that matured in September were superior to the 'Victoria' and 'VicS' controls; while the genotypes GD7, GD43, and GD45 and GD47 that matured in June, July and August, respectively, produced fruit of greater dimensions than the controls. The eleven selected genotypes may be validated in uniform orchards with cooperating Zacatecan producers or in other regions of the country with similar agroecological characteristics.

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