EFFECT OF FRUIT-SET TIME ON THE QUALITY PERFORMANCE OF *ANNONA CHERIMOLA* MILL. FRUIT IN SOUTH ITALY

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Abstract

The aim of this work was to analyze the differences between fruits obtained by different dates of fruit set and identify the proper fruit-set time that allows to obtain the optimum fruit quality in *Annona cherimola* cv Fino de Jete, planted in Southern Italy. Six fruit-set dates were selected from the first week of June to the second week of July. Fruits were sampled from October to November, when 1500 Growing Degree Days (DD) were accumulated; The DD were calculated using a base temperature of 12 °C. Fruit fresh weight (FW) and skin colour were measured. These parameters were measured also after

storage, and in addition, the following parameters were measured: fruit shape (FS), pulp colour, pulp firmness, number of seeds, total soluble solids content (TSSC), titratable acidity (TA), ascorbic acid (AA), total polyphenol content (TPC), total antioxidant capacity (TAC) and fruit dry weight (DW). Moreover, fruit dry weight percentage, fruit fresh weight loss (FWL), and the seed index were calculated after storage.

The fruit development period changed from 120 to 146 days with the fruit-set date. The average seed number decreased with fruit set date. A strong correlation between fruit size and seed number occurred and also between the H/D ratio and number seed. FW decreased significantly from the third week of October to the first week of December and FS became progressively less regular in fruit coming from the 4th week of November to the 2nd week of December. From second to five sampling the AA was highest and similar. The lowest values of TAC were measured in the November and early December. The correlation between TAC and AA was stronger compared to TAC and TPC. All quality parameters of *Annona cherimola* fruit have reached the standards required by the market when 1500 DD have been accumulated from fruit-set. Eventually, the optimal period for fruit set ranged from end of June to the beginning of July.

Abbreviation:

Growing Degree Days = DD; fruit fresh weight =FW; fruit dry weight (DW); Total soluble solids content (TSSC), titratable acidity (TA), ascorbic acid (AA), total polyphenol content (TPC), total antioxidant capacity (TAC) fruit fresh weight loss (FWL).

Keywords: Degree Days, Antioxidant, Ascorbic Acid, Polyphenol, , fruit shape, Fino de Jete

1 Introduction

Annona cherimola (*cherimoya*) is cultivated in a restricted area in Southern Italy, characterized by specific pedoclimatic conditions (Loizzo et al., 2012). The flowering period of *A. cherimola* is very long (Gazit et al., 1982; Gottsberger, 1989); pollination and fruit set can last from the first decade of April to the end of August, also depending on the rate of leaf drop in late winter. Furthermore, both floral biology and fruit development will depend on climatic conditions from pollination to harvest time.

Fruit harvesting time is determined by skin colour, which changes from dark to light green or greenish-yellow in proximity to physiological maturity (Pal and Kumar, 1995; Pinto et al., 2005). Cherimoya is a climacteric fruit. The ripening process occurs during climacteric respiration, and the ripening occurs very quickly after harvest (Torres and Sanchez, 1992). Indeed, high levels of ethylene (up to 100-300 µl/kg hr^{-1}, depending on cultivar) are produced during ripening and the optimum harvesting stage, for eating, occurs at the peak of ethylene production (Paull, 1982; Paull et al., 1983). This accounts for fruit perishability that happens soon after ripening.

Cherimoya fruit reaches their best quality when practically 1470 Growing Degree Days (DD) are accumulated (Pinillos, 2013). The long flowering period, particularly in the Mediterranean geographic areas, may influence the variability of fruit characteristics at harvest time, which occur over two-three months. When ripe they may reach high concentrations of soluble sugars (14-15%) and moderate titratable acidity (0.4-0.7%). They are good sources of ascorbic acid (45-60mg/100g) and potassium (250-500mg/100g edible portion) (Pareek et al., 2011).

In a respiratory study, it was found that the fruit had a peak respiratory climacteric after 4 and to 5 days from harvest (Biale et al., 1954). Brown et al., (1988) have found a second larger peak after ten days and that the fruit softened and developed a characteristic flavor and aroma during the second respiratory rise.

The aim of this research was to analyse the differences between annona fruits obtained by different dates of fruit set, from April to August, and harvested from October to November. In this study, the focus will be to define the period where fruit-set allows to obtain: a) fruits of optimum shape and size; b) excellent organoleptic and nutraceutical features; c) better fruit shelf-life.

2 Materials and methods

2.1 The Orchard

The orchard of *Annona cherimola* cv *Fino de Jete* grafted on seedling rootstocks, was planted in Reggio Calabria, Italy, (latitude, 39 43047.8100 N; longitude, 16 13052.4800 E), in 1994 with a North-South plant orientation in a sandy soil of pH 6.9, with medium organic matter content (1.18%).

Trees were spaced 5x5 m apart, and the orchard was managed using the standard integrated pest management system and stable drip irrigation and fertilisation system.

2.2 The experiment layout

The experiment was carried out during two years (2016 and 2017).

Flowers were hand pollinated from the first decade of April to the end of August when the stigma was receptive, and the flower was fully open. Fruit-set ranged from 95% to 100% of pollinated flowers.

2.3 Fruit samples

Six fruit-set dates were weekly selected from the first week of June to the second week of July (Table 1).

The fruit was harvested when 1500 Degree Days (DD) were accumulated from fruit-set date at harvest time (Pinillos, 2013). The DD were calculated according to Zalom et al. (1983) using a base temperature of 12 °C.

According to this, fruit sampling started in the first week of October until the second week of December. Each year, fruits were selected at fruit set time, and their development was measured from fruit-set to harvest.

For each fruit-set date, 108 fruits were selected [6 replicates (fruits) x 6 treatment (fruit-set date) x 3 blocks (each tree was considered a single block)]. For each sampling, the 50% was used for measurements and analysis at harvest time and the 50% after storage

2.4 Fruit measurements

Fresh weight (FW) was determined immediately after harvest at each sampling date and after storage for 4 d at 20 °C, using an electronic balance (Mettler-Toledo MgbH, Grelfensee, Switzerland). At the end of the storage period, fruit weight loss (FWL) was calculated as the difference between fresh weight measured after and before storage and expressed as a percentage on a fresh weight basis.

The polar and equatorial diameter at the maximum width was measured (in millimeters). At each harvest time, fruit shape was determined as -fruit height to diameter (H/D) ratio as symmetry between fruit longitudinal section: percentage distribution on fruit longitudinal face of two parts separated by a perpendicular and central ideal plane to the longitudinal section. Therefore a digital image processing software (Adobe Photoshop

CS6 Extended, 2012) and the analysis tool (Stanley and Baker, 2002) allowed determining the area of the cross-section, which has been expressed in cm^2.

The scale adopted by George and Nissen (1988), ranging from 1 (irregular) to 5 (regular), was used to measure fruit symmetry index.

2.5 Colour determination

Skin and pulp colour were also measured at harvest and at ripening, for each sampling, in terms of CIELAB (L*, a*, b*) and HSL (L*, Chroma, °Hue). To evaluate CIELab coordinates, we used a portable spectrophotometer (CM 700d, Konica Minolta, Tokyo, Japan) with a D65 illuminant, previously calibrated with a white ceramic tile. Chroma value was calculated as $[(a^{*2} + b^{*2})^{1/2}]$ and represents the hypotenuse of a right triangle created by joining points (0,0), (a*, b*) and (a*, 0); °Hue value was calculated as [(arctan (b*/a*)]; it is defined as the angle between the hypotenuse and 0° on the* axis (Mc Guire, 1992).

2.6 Fruit analysis

At harvest and after storage, fruits were analysed to determine firmness (kg cm^{-2}) using an 8-mm-diameter penetrometer with a metal point (PCE 100, Padova, Italy), total soluble solids content (TSSC), using a hand-held digital refractometer (PR-1, Atago, Japan) and titratable acidity, using 10 ml annona juice diluted with distilled water (1:1) and titrated to pH 8.2 with 0.1 N NaOH (mEq. NaOH/100 gr. fresh fruit). The determined values were expressed in mg of malic acid/100 ml of juice.

Dry matter concentration was determined on 36 fruits sampled at harvest, using a standardized sampling method: a horizontal slice of fruit tissue of the equatorial zone was extracted from each fruit. The thickness of the slice was about 1 cm and the fresh weight was recorded. The slice was placed in a dehydrator at 70 °C until the constant dry weight was reached. The dry matter content (DMC) was expressed as a percentage on fresh weight and was determined at each harvest time.

After these evaluations, the number of seeds counted and the seed index was calculated as the number of seeds per 100 g of fruit fresh weight (Richardson and Anderson, 1996). Ascorbic acid (AA) content in annona juices was estimated by the volumetric method, using the procedure based on the reduction of the dye 2.6-dichlorophenol-indophenol (DIP) by ascorbic acid. Annona fresh tissue (3g) was mixed with 20 ml (3%) metaphosphoric acid and homogenized. Ascorbic acid was determined by titration of 15

ml filtrated juices by DIP containing bicarbonate sodium. The measures were expressed as mg of ascorbic acid /100 g FW.

On 20g of pulp per fruit, the analysis of total polyphenol content (TPC) and total antioxidant capacity (TAC) carried out at harvest and after storage. Fruit samples were homogenised using an Ultraturrax bender (20.000 rpm; T 25 Basic, IKA Werke, Germany). The TPC and TAC were analysed separately using a Kontron Uvikon 941 Plus spectrophotometer. Before measuring the TPC and TAC, standard curves were prepared for each test. The TPC (mg gallic acid equivalents/l) was determined using the Folin-Ciocalteu method (Slinkard and Singleton, 1997). The TAC was determined using the modified TEAC assay and expressed as mmol Trolox equivalents/g fresh weight (FW) (Pellegrini et al., 1999; Re et al., 1999).

2.7 Experimental layout and statistical analysis

The experiment was set up in a randomized block design, with three randomized blocks made of 3 single tree replicates per treatments (six fruit-set dates) in each block.

All the data were analyzed using ANOVA to determine the significance of differences between sampling and treatments which consisted in harvest time.

Differences were calculated according to the Tukey's test being considered significant at $P \leqslant 0.05$. The correlation analysis of the TPC vs. TAC and AA vs TAC were performed using the statistical software TIBCO Statistica™ v.10 (Statsoft Inc., (Tulsa, USA).

3 Results and discussion

The average week temperature increases rapidly during June. During the next two months, the increase was slower, and it reached the maximum during the last two weeks of August and decreased from the first week of September (Fig. 1).

Fruit fresh weight average was 399.40 g (±11.09) and decreased significantly only from the first week of November to the first week of December (Table 1). The fruit development period changed with the fruit set date, considering that in any case fruits were harvested when 1500 DD were reached. Indeed, fruit that set during the first three weeks of June reached harvest time 120-127 days after set, while those that set from the 4^{th} week of June to the 2^{nd} week of July took 135 to 146 days to ripe, respectively. Fruit variability, in terms of fresh weight, was higher during the last harvest date, corresponding to the last flowering dates. Overall, fruit fresh weight measured from October to December was in the range reported in the literature for *Annona cherimola*

(Vasco et al., 2008). The average seed number decreased with fruit set date, along with fruit weight (Table 2), and a strong correlation between fruit size and seed number occurred (Fig. 2) (Kahn et al., 1994; George et al., 1986). In the fruit obtained by first three fruit set dates, the number of seeds was similar to the amount reported by Gonzalez et al. (2006).

The long flowering period (from May to Mid-August) with large temperature and humidity changes may have an effect on pollination and both protogyny and dichogamy (Gazit et al., 1982; Gottsberger, 1989). Indeed, during the warm season, the higher temperatures can delay the opening of female flowers on the first day of the flower cycle (Lora et al., 2009) and may increase the speed of stigma desiccation on the second day of the flower cycle, shortening the duration of stigmatic receptivity. Then, the pollination process from fifth fruit-set may have been less effective compared to those before. Higuchi et al. (1998) found that fruit set at warm temperatures was hindered, and ascribed this response to both pollen and stigmatic damage from heat stress.

No difference occurred regarding fruit dry weight and fruit component partitioning in terms of percent fresh weight (Table 1). The percentage of pulp was 85% of total fruit fresh weight at harvest (Table 1), and it was higher than that reported by Vasco et al. (2008). The peel and seed accounted respectively, for 10% and 5% of fresh weight. These percentages did not change with the fruit-set date (Table 1).

Fruit weight loss during storage changed inconsistently with fruit set and harvest date (Table 1).

Fruit coming from the first three fruit set dates had the highest H/D ratio (> 1) (Table 2). H/D decreased significantly in fruit coming from the later fruit set dates, to be lowest in the last one. A strong correlation was also found between the H/D ratio and number seed (Fig. 3).

The same behavior occurred regarding fruit symmetry and symmetry index. Fruit shape became progressively less regular from the 1st week of November to the 2nd week of December (fruit set dates from 4th week June to 2sn week July) The symmetry index decreased accordingly) (Table 2).

Indeed, the pollination process has an important role in the number and distribution of seed and then in the symmetry of the fruit (Kahn et al., 1994; Jalikop and Kumar, 2007).

Although pulp firmness was not found to be predictive of maturity (Tietz, 1988), it declined progressively with delayed fruit set, but no significant differences were observed from the third to the last sampling date (Fig. 4). No relationship, between firmness at harvest and post-harvest values, was also found in relation to fruit set date (Fig.4).

Fruit set and fruit harvest date had no effect on fruit titratable acidity (TA), that increased after storage, (Silva et al., 2013) (Table 3). The increase in acidity can be ascribed to the production of organic acids during ripening of the cherimoya (Gutierrez et al., 1994).

TSSC decreased significantly from the 1st week of November to the 1st one of December. Indeed, Pavez (1985) reported a high correlation between soluble solids evolution and fruit diameter during growth. After harvest, starch degradation and its conversion to glucose determined the increase in TSSC, and the differences in TSSC observed between samples at harvest disappeared (Table 3). In other words, the sweetness of the fruit was not affected by fruit harvest time, provided they had accumulated at least 1500 DD from fruit set to harvest time. Indeed, for all samples, TSSC exceeded the value (22 °Brix) reported by Gutierrez et al. (1994). This aspect is very important also because the development of flavour of ripe in cherimoya is correlated with the soluble solids content (Paull, 1982).

At harvest, the ascorbic acid content increased from first (15 mg/100 g FW) to the second harvest (25 mg/100 g FW) and remained stable until the last week of November. Successively, it decreased significantly to the last harvest, at the 2nd week of December (11.12 mg/100 g FW) (Table 3). Each sample has shown a rapid decrease in the ascorbic acid content after six days of ripening at 20 °C, according to what observed in other species of Annona (Patil et al., 2014): the first and last sampling showed the lowest AA content whereas from second to five sampling the value was higher and similar (Table 3). However, the AA content was always within the range reported by Pareek et al. (2011). The reduction in AA content might be due to the activity of oxidative enzymes (ascorbic acid oxidase) during ripening/storage, leading to the oxidative reduction of vitamin C in the presence of molecular oxygen (Pruthi et al., 1984). The TPC slowly increased after the first harvest (Table 4), but the values were lower compared to those reported in the literature (Vasco et al., 2008).

The TAC was higher than the values reported by Loizzo et al. (2012). The lowest values were measured in the two latest harvest dates, in late November and early December

(Table 4). A close correlation was measured between TAC and TPC and AA content (Fig. 5). However, Pearson's correlation coefficient showed that the latter correlation is stronger than the former. The increase of polyphenols content occurred along with the decrease of temperature during the last harvest dates (data not shown); a similar pattern was observed in other climacteric fruits, like kiwifruit (Gullo et al., 2016). Indeed, Tomás-Barberán and Espin (2001) reported that PAL activity is higher to lower temperature and at the same time, the activity of enzymes responsible for polyphenol degradation, polyphenol oxidase, is inhibited by lower temperatures (Leja et al., 2001).

Rapisarda et al. (2008) also reported that low temperatures in orange fruit, increase various bioactive compounds, such as anthocyanins, flavanones, hydroxycinnamic acids, and total phenolics. Shivashankara et al. (2004) suggested that an increase in the TAC during cold temperature may be possible only with fruit for which the contribution of total phenolics is greater compared to AA that decreases.

The time of harvesting is determined by fruit skin colour which changes with the proximity of physiological maturity: from dark to light green or greenish-yellow (Pal and Kumar, 1995; Pinto et al., 2005). L* (lightness) was always over 60 whereas no significant differences were observed for Chroma (Table 5). This last was always above 35. Berger and Galleti (2005) reported that the L* (lightness) and Chroma values, over 55.5 and 36 respectively, are optimal quality parameters for the export fruit of the cherimoya

The colour of the skin changed significantly after storage, but the differences were not significant among the harvest date. We recorded a significant decrease of L* (5 points) an increase of a* (+2.7 points; less green), a decrease of b (3 points; less yellow), of Chroma (3 points), and Hue (2.40 points) (Data not shown).

The pulp colour parameters did not significantly change with harvest date, and we didn’t observe significant differences among sampled times (Table 6). After storage, L* parameter decreased (about 15 points), whereas other parameters did not change (data not shown).

4 Conclusions

All quality parameters of *Annona cherimola* fruit have reached the standards required by the market when 1500 DD have been accumulated from fruit-set, according to (Pinillos et al, 2013).

In the population of the fruit of *Annona cherimola* tree, the parameters L* and Chroma are a valid index to identify the optimum time for harvesting, as shown by Berger and Galleti (2005).

By counting DD it was identified the period between the end of June and the beginning of July as the optimal period for fruit-set because the fruits are qualitatively better no only for their organoleptic and nutraceutical characteristics but also with regard to the regular shape of the fruit.

Table 1 - Fresh weight, dry weight (percentage on fresh weight), fresh weight of pulp, seed, and peel (as a percentage on whole fresh weight), fresh weight loss after shelf life (percentage on fresh weight at harvest) in the fruit of Annona cherimola cv Fino de Jete in relation to fruit-set and fruit harvest time. All fruits were harvested when **1500 DD** had accumulated from fruit set. (Data are means of 2016-2017 ±SE).

Fruit set date	**Harvest date**	**Fresh weight (g)**		**Dry weight (%)**		**Fruit component weight (%)**						**Fresh weight Loss (% fw)**	
						Pulp		**Seed**		**Peel**			
		Mean	± SE	Mean	± SE	Mean	± SE	Mean	± SE	Mean	± SE	Mean	± SE
1st week June	1st week October	423.5a	13.9	55.6ns	7.0	84.2n.s	0.02	5.1n.s.	0.01	10.2ns	0.02	10.0b	2.0
2sn week June	2 sn week October	417.8a	13.2	57.8	6.4	85.1	0.02	5.0	0.03	10.4	0.02	14.6a	1.6
3rd week June	4th week October	412.2a	12.5	62.4	6.9	85.4	0.03	4.8	0.03	9.8	0.03	12.3a	1.5
4th week June	1st week November	390.5b	17.6	64.1	0.6	84.8	0.02	4.9	0.01	9.4	0.02	9.0b	1.7
1st week July	4th week November	360c	21.5	58.7	3.4	84.8	0.02	5.2	0.02	10.1	0.02	6.3c	1.6
2sn week July	2sn week December	203.2d	29.3	60.6	5.9	84.2	0.01	5.1	0.01	9.9	0.01	13.0a	1.7

Different letters indicate significant differences $P \leq 0:05$; ns: no significant differences at $P \leq 0:05$.

Table 2 - Seed number (n°), H/D ratio, symmetry compared to central axis in longitudinal section (%), and symmetry index in the fruit of Annona cherimola cv Fino de Jete at harvest time. All fruits were harvested when 1500 DD had accumulated from fruit set. (Data are means of 2016-2017 ±SE).

Fruit set date	**Harvest date**	**Seed (n°)**		**H/D Ratio**		**Symmetry between longitudinal fruit sections (%)**		**Symmetry index**	
		Mean	± SE	Mean	± SE	Mean	± SE	Mean	± SE
1st week June	1st week October	33.4a	1.2	1.1a	0.02	49.6a	1.1	5a	0.02
2sn week June	2 sn week October	28.5a	1.15	1.1a	0.03	49.7a	1.1	5a	0.02
3rd week June	4th week October	27.4a	1.05	1.0a	0.05	48.5a	0.9	5a	0.01
4th week June	1st week November	21.3b	1.23	0.9b	0.03	35.8b	1.7	4.2b	0.03
1st week July	4th week November	19.8b	1.10	0.8b	0.02	26.5c	1.0	3.3c	0.02
2sn week July	2sn week December	6.4c	0.85	0.7c	0.02	9.2d	1.5	1.2d	0.01

Different letters indicate significant differences $P \leq 0:05$; ns: no significant differences at $P \leq 0:05$.

Table 3 - Total soluble solids and titratable acid (TA) in the fruit of *Annona cherimola* cv *Fino de Jete* at harvest and after shelf life (7 d of storage at 20 °C). All fruits were harvested when 1500 DD had accumulated from fruit set. (Data are means of 2014-2015 ±SE).

Fruit set date	**Harvest date**	**Total soluble solids (°Brix)**				**Titratable acidity (g/l)**				**Ascorbic acid mg/100 gr FW**			
		Harvest		After 7 d of storage at 20 °C		Harvest		After 7 d of storage at 20 °C		Harvest		After 7 d of storage at 20 °C	
		Mean	± SE	Mean	± SE	Mean	± SE	Mean	± SE	Mean	± SE	Mean	± SE
1st week June	1st week October	10.7a	0.7	23.7n.s.	0.6	1.5ns	0.04	2.5ns	0.1	15.02b	1.22	4.88b	1.26
2sn week June	2 sn week October	9.3a	1.4	25.4	0.3	2.6	0.09	3.3	0.2	25.75a	1.83	11.39a	1.89.
3rd week June	4th week October	8.8a	1.1	24.0	1.0	1.9	0.07	5.6	0.8	26.22a	2.46	11.53a	1.19
4th week June	1st week November	7.8b	0.7	24.0	0.7	1.4	0.13	3.4	0.2	26.93a	1.92	10.938a	1.82
1st week July	4th week November	7.4b	0.3	22.4	1.2	1.7	0.17	3.7	0.4	26.54a	2.44	11.87a	1.76
2sn week July	2sn week December	6.8c	0.5	22.3	1.3	1.8	0.10	2.8	0.4	11.12b	1.80	4.758b	1.10

Different letters within each column indicate significant differences $P \leq 0.05$; ns: no significant differences at $P \leq 0:05$.

Table 4 - Total Antioxidant Capacity (TAC) and Total Polyphenols Content (TPC) in *Annona cherimola* fruit, cv. *Fino de Jete*, at a ripening after 7 d of storage at 20 °C. All fruits were harvested when 1500 Degree Days had accumulated from fruit set. (Data are means of 2014-2015 ±SE).

Fruit set date	**Harvest date**	**TAC** **µmoli Trolox/g FW** **After 7 d of storage at 20 °C**		**TPC** **mg GAE/g FW** **After 7 d of storage at 20 °C**	
		mean	± SE	mean	± SE
1st week June	1st week October	5.6b	0.4	1.09c	0.08
2sn week June	2 sn week October	5.8bc	0.3	1.27b	0.06
3rd week June	4th week October	6.8a	0.4	1.37b	0.08
4th week June	1st week November	6.4ab	0.4	1.34b	0.10
1st week July	4th week November	5.2c	0.2	1.42a	0.09
2sn week July	2sn week December	4.9c	0.4	1.41a	0.07

Different letters indicate significant differences $P \leq 0:05$; ns: no significant differences at $P \leq 0:05$.

Table 5 – Skin colour parameters at harvest regarding CIELAB (L*, a*, b*) and SL (L*, Chroma, °Hue) colour space. All fruits were harvested when 1500 DD had accumulated from fruit set. (Data are means of two years ±SE).

Fruit set date	**Harvest date**	**L***		**a***		**b***		**Chroma**		**°Hue**	
		mean	±SE	mean	±SE	mean	±SE	mean	±SE	mean	±SE
1st week June	1st week October	63.34b	0.83	-7.56c	0.15	29.77n.s.	0.63	35.01n.s.	0.62	104.27a	0.30
2sn week June	2 sn week October	65.78ab	1.03	-7.57c	0.28	31.04	0.67	35.26	0.67	103.729ab	0.48
3rd week June	4th week October	66.39ab	1.54	-7.25bc	0.51	30.31	0.79	36.19	0.77	103.49ab	1.01
4th week June	1st week November	68.59a	0.87	-6.15abc	0.24	30.87	0.72	36.49	0.72	101.29bc	0.46
1st week July	4th week November	68.46a	0.82	-5.98a	0.42	31.80	0.91	36.39	0.89	100.73bc	0.80
2sn week July	2sn week December	67.22a	0.53	-5.10a	0.40	32.29	0.38	37.72	0.42	98.91c	0.63

Different letters indicate significant differences $P \leq 0:05$; ns: no significant differences at $P \leq 0:05$

Table 6. Pulp colour after 7 d of storage at 20 °C at harvest regarding CIELAB (L*, a*, b*) and HSL (L*, Chroma, °Hue) colour space. All fruits were harvested when 1500 DD had accumulated from fruit set. (Data are means of two years ±SE).

Fruit set date	**Harvest date**	**L***		**a***		**b***		**Chroma**		**°Hue**	
		mean	±SE	mean	±SE	mean	±SE	mean	±SE	mean	±SE
1st week June	1st week October	85.54n.s.	0.99	0.49n.s.	0.34	15.99n.s.	0.74	15.99n.s.	0.75	92.01n.s.	0.98
2sn week June	2 sn week October	86.24	0.48	0.17	0.16	15.16	0.69	15.16	0.70	90.74	0.44
3rd week June	4th week October	86.20	0.84	0.23	0.36	14.85	0.67	14.86	0.68	91.46	0.97
4th week June	1st week November	85.65	0.60	0.14	0.13	14.30	0.22	14.30	0.22	90.81	0.30
1st week July	4th week November	86.71	0.05	0.34	0.27	14.52	0.25	14.53	0.24	91.37	1.12
2sn week July	2sn week December	85.73	0.87	0.19	0.17	15.65	0.58	15.65	0.59	90.74	0.54

Different letters indicate significant differences $P \leq 0:05$; ns: no significant differences at $P \leq 0:05$

Fig. 1 – Trend of daily temperature from June to December (mean of ten years 2016/2017).

Fig. 2 - Correlation between fruit fresh weight and number of seeds in *Annona cherimola cv Fino de Jete* fruit, harvested in six-date, from 1st week October to 2sn week December (2017). Each point is mean of each treatment per year (2016/2017); n=12.

Fig. 3 - Correlation between the ratio H/D and its number seeds in *Annona cherimola* fruit, cv *Fino de Jete*, harvested in six-date, from 1st week October to 2sn week December. Each point is mean of each treatment per year (2016/2017); n=12.

Fig. 4 – Fruit firmness at harvest and after 7 d of storage at 20 °C in *Annona cherimola* fruit, cv *Fino de Jete*., harvested in six-date, from 1st week October to 2sn week December [n=108 (2016); n=108 (2017)].
Different letters indicate significant differences P ≤ 0:05; ns: no significant differences at P ≤ 0:05.

Fig. 5 - Correlation between TAC *vs.* PTH and TAC *vs*. AA in Annona Cherimola fruit, cv *Fino de Jete,* harvested in six-date, from 1st week October to 2sn week December. Each point is mean of each treatment per year (2016- 2017); n=12.

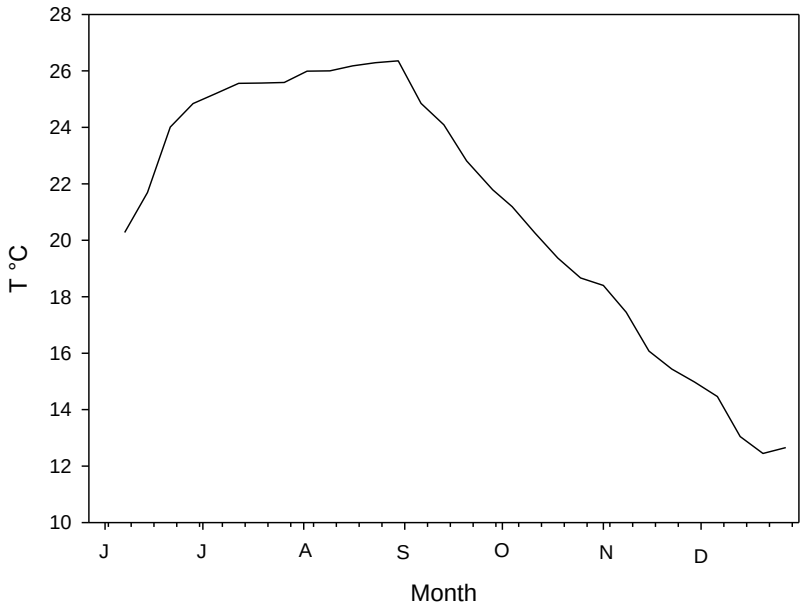

Fig. 1

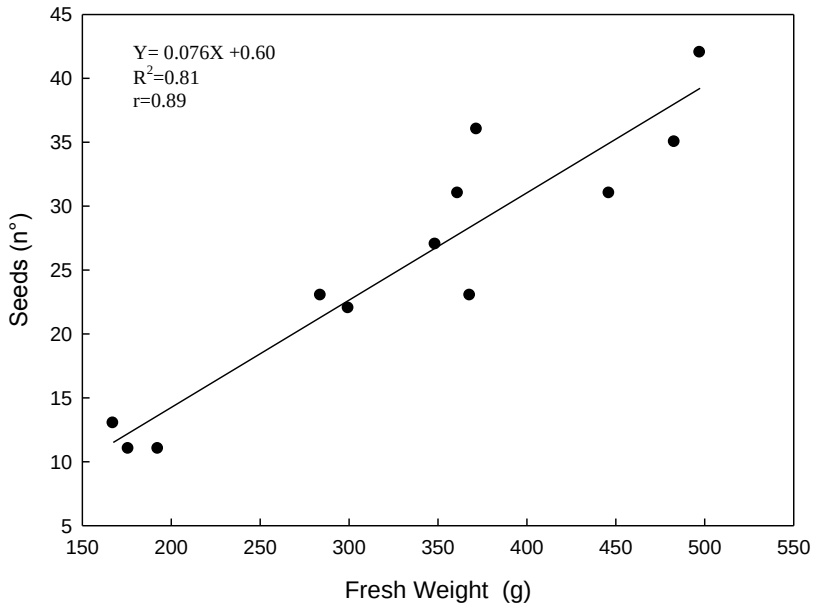
Y= 0.076X +0.60
R2=0.81
r=0.89
Seeds (n°)
Fresh Weight (g)
45
40
35
30
25
20
15
10
5
150
200
250
300
350
400
450
500
550

Fig.2

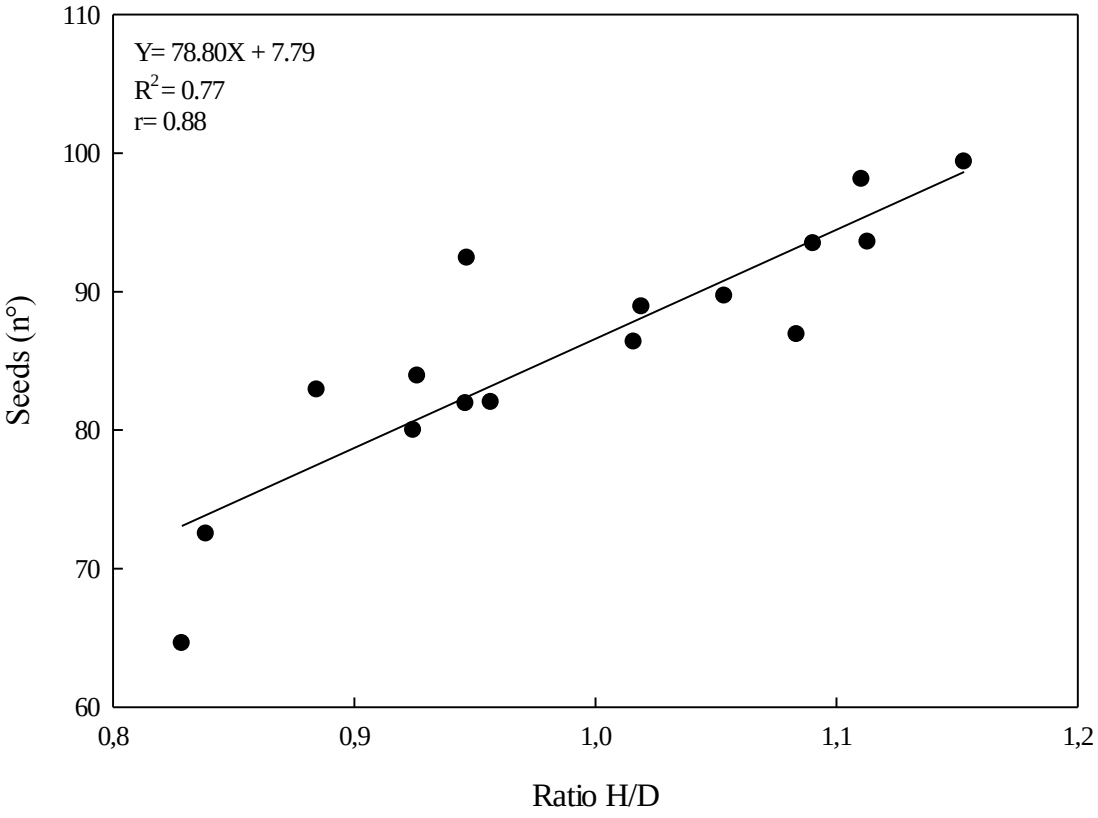
Y= 78.80X + 7.79
R2= 0.77
r= 0.88
Seeds (n°)
Ratio H/D
110
100
90
80
70
60
0,8
0,9
1,0
1,1
1,2

Fig. 3

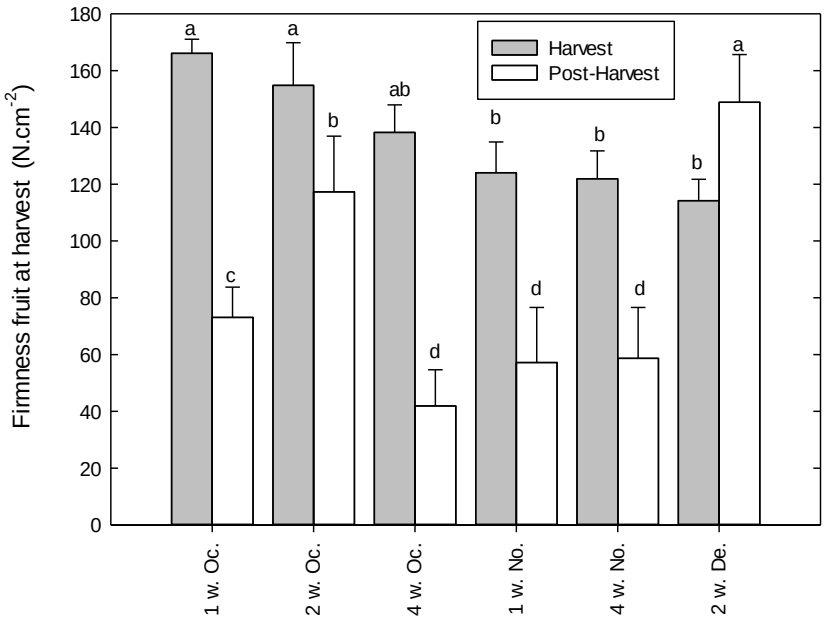
Firmness fruit at harvest (N.cm-2)
180
160
140
120
100
80
60
40
20
0
Harvest
Post-Harvest
a
a
ab
b
b
b
a
c
b
d
d
d
1 w. Oc.
2 w. Oc.
4 w. Oc.
1 w. No.
4 w. No.
2 w. De.

Fig. 4

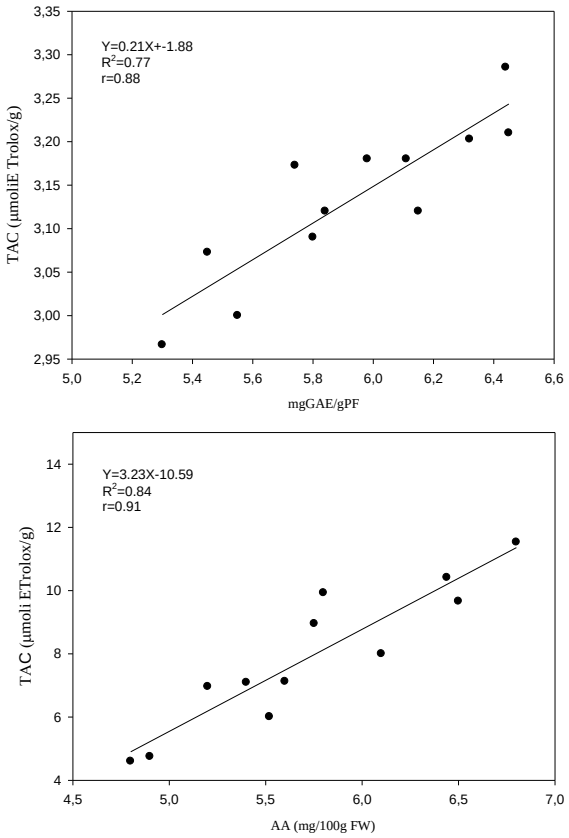

Fig. 5

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