

Effect of Cultivar and Crown Size on Yield and Quality of Strawberry Fresh Bare Root Plants in Sicily

D'Anna, G. Caracciolo, A. Moncada and F. Vetrano
Dipartimento di Agronomia Ambientale e Territoriale Sez. di Orticoltura e Floricoltura
Università degli Studi di Palermo
Italy

Keywords: 'Candonga', 'Nora', starch content, crown diameter

Abstract

In the southern regions of Mediterranean areas the plantations with fresh plants (winter planting system) have almost completely replaced those with cold stored plants (summer planting system). Particularly, fresh bare root plants produced in high elevation nurseries located in Spain and Poland and, in experimental phase, in the southern of Italy (in the mountains of Sicily, Calabria, Basilicata) are the most used. Such type of plant usually has a crown diameter from 8 to 14 mm, but the smallest plants should be (<8 mm) discarded in phase of selection and packing. Objective of this study was to investigate the influence of the different crown diameter on the earliness, productivity and quality of two new cultivars of strawberry. The research was carried out in 2007/08 in the experimental plots located in Palermo. Three typologies of fresh bare-root plants (small plants: crown diameter 6-8 mm; medium plants: 8.1-11 mm and large plants 11.1-14 mm) and two cultivars ('Candonga' and 'Nora') were compared. The experimental design was a split-plot with 3 replication and individual experimental plot of 4.6 m². The plantation was established the 22nd of October in a plastic greenhouse of 600 m², on two-row beds and at a plants density of 9.1 plant/m². The production started in January and finished in May. The medium plants (crown diameter 8.1-11 mm) were earlier than the others types. The marketable production during the whole harvesting period was influenced by crown diameter. Large and medium plants (crown diameter 8.1-14 mm) produced more than small plants (crown diameter 6-8 mm) (respectively 590 and 551 g/plant). 'Candonga' (586.8 g/plant) produced more than 'Nora' (567.9 g/plant). The average strawberry weight wasn't statistically influenced by the typology of plant but by the cultivar; 'Candonga' produced the biggest fruits. The crown diameter of fresh plants influenced earliness and productivity of strawberries. To ensure high production it should be use medium and large fresh plant with a crown diameter from 8.1 to 14 mm.

INTRODUCTION

In Sicily the largest strawberry production area is located near Marsala (Trapani) and covers about 380 hectares. The productivity increase of cold stored plants is carried out by a loss of earliness and quality of the fruit (size, shape) (Hennion et al., 1997). In the last decade, cold stored plant have been almost completely replaced by fresh bare root plant which require less management (with these plant can be avoid the old runner removal) and less input (as water and fertilizer), which give more interesting performance because of a very long fruiting season (from December to May) and an earlier and greater total fruit production (Moncada et al., 2009). For every strawberry cultivation system, several factors are cited to justify that successful production depends on a supply of high quality plants (Johnson et al., 2005): little plants will perform poorly in the production field, early modification in the first vegetative phase can impact fruit yield, strong and robust plants establish more quickly and easily. It was verified that plant size is important because flower number increases with increased daughter plant crown diameter (Jemmali and Boxus, 1993) and that crown diameter is linked not only to size and number of flower trusses but to the inflorescence initiation too (Mason, 1987). Fresh bare root plants are produced in nursery field where variability in plant size can occur because of the

developmental differences in vegetatively propagated daughter plants and because of the digging process that can destroy part of the roots and reduce the total starch content. This variability has important implications for fruit production (Bish et al., 2003) because much of the variation has been just attributed to the carbohydrates content in the plant crown that represents an important reservoir of starch. It has been reported that an increase in fruit yield have been obtained in plants with high initial starch levels in the roots (Macias-Rodriguez et al., 2002; Wang and Camp, 2000; Maas, 1986); even strawberry number and average fruit weight seem to be positively correlated to crown size (Le Mière et al., 1998). However, the optimum transplant size has not yet been elucidated (Johnson et al., 2005); Popenoe and Swartz (1985) suggested that the importance of yield components depends on the cultivar and the production system while other authors indicate that the optimum crown size has to be determined for each individual cultivar (Chercuitte et al., 1991). Objective of this study was to investigate the influence of the different crown diameter on the earliness, productivity and quality of two new cultivars of strawberry.

MATERIALS AND METHODS

The research was carried out in 2007-2008 on the experimental farm of the Horticultural and Floricultural Branch of the Department SAGA of the University of Palermo. Two cultivars ('Candongia' and 'Nora') and three crown size were compared (small plants: crown diameter 6-8 mm; medium plants: crown diameter 8.1-11 mm; large plants: crown diameter 11.1-14 mm). Plants were obtained from a high elevation nursery located at Cammarata (800 m of altitude), where mother plants produced runners which remained hanging above the ground. At the required planting date, fresh bare root plants were rooted out and transplanted in a loam soil, in a unheated greenhouse-tunnel of 600 m² covered with polyethylene, in a split plot design with 3 replication and individual experimental plot of 4.6 m². It was adopted the typically cultivation technique, according to the standard growing system for the area (D'Anna et al., 2007): in August the soil was ploughed and disced, then it was improved with the addition of 100 t/ha of exhausted grape marc before mulching. Before transplanting, 50 kg/ha of N, 150 kg/ha of P₂O₅, 150 kg/ha of K₂O and 60 kg/ha of S were added. Then, a microirrigation system was placed upon the soil, arranged with raised bed (40 cm), and used for drip fumigation with chloropicrin + 1,3-dichloropropene, 30 days before transplant. Plantation was established the 22nd of October on two-row beds and at a plants density of 9.1 plant/m². Greenhouse was covered with EVA in the in the 2nd decade of November. After transplant, fertilization was conducted by fertirrigation; on the whole, 230 kg/ha of N, 80 kg/ha of P₂O₅ and 170 kg/ha of K₂O were given. Fruit were harvested twice a week for yield and quality evaluation. Data were collected on marketable and unmarketable fruit yield, average fruit weight, fruit hardness and solid soluble contents. The fruit flesh firmness was measured with a Chantillon penetrometer (with a mm 6 plunger) and the solid soluble content (°Brix) using a digital refractometer. Data were statistically analysed by analysis of variance and mean separation was performed by Duncan's multiple range test.

RESULTS AND DISCUSSION

The production started in January (only one harvest) and ended in the last ten days of May, although all the plants produced very little until February. In the first month of harvest, no statistically significant differences were found among the cultivars that produced on average 82.8 g/plant. Regarding crown size the maximum yield was obtained by plant with a diameter of 8.1-11 mm (87.6 g/plant), although not differing significantly from plants of 11.1-14 mm crown size (85.5 g/plant) (Table 1). The highest yield was reached by the plants of 'Nora' with crown size of 8.1-11 mm (75.7 g/plant) followed by the plants of 11.1-14 mm (68.1 g/plant) (Fig. 1). No statistically significant differences were found among fruit production in March, both regarding the cultivars and the crown size. The results indicate the same trend during April: no differences were observed between the cultivars or between plant with different crown size. 'Candongia' plants of

11-11 mm of diameter were the most productive (236.6 g/plant), followed by plants of the same cultivar but with a bigger crown size (228.7 g/plant) (Fig. 1). The lowest yield (133.5 g/plant) was observed with 'Nora' plants of crown size of 8.1-11 mm. Median values were observed among the other thesis. In May, 'Candongga' was the most productive (170.9 g/plant), while regarding the crown size the highest yield was reached by the plants of crown diameter included among 11.1 and 14 mm (168.9 g/plant) (Table 1). The interaction shows the best performance of the large plants of 'Candongga' (183.7 g/plant) followed by the medium one (165.0 g/plant) and by the small one (164.0 g/plant); 'Nora' showed the lowest yield, especially with a crown size of 6-8 mm (130.5 g/plant) (Fig. 1). At the end of the productive cycle, no statistically significant differences were found between the cultivars; regarding the plant size, the bigger crown produced on average 590.3 g/plant while the plants with a crown size of 6-8 mm were the less productive (551.5 g/plant) (Table 1). The maximum yield was observed by plants with a large crown of 'Candongga' (on average 604 g/plant) followed by 'Nora' (on average 576 g/plant) while no statistically significant differences were found between the plants of 6-8 mm of diameter of both the cultivars (Fig. 2). No differences among the thesis were observed regarding fruit size, except for the first period of picking. During the first month of harvest, 'Candongga' gave the best result with an average fruit weight of 19.9 g while no statistically significant differences were found among the other thesis (Table 2). Even the interactions were often not significant (Fig. 3). Considering the general fruit average weight, the largest fruit weight was obtained with 'Candongga' (16.6 g) while 'Nora' fruit weighed only 14.7 g. The plants with different crown size showed fruits with a weight ranging from 15.2 g (11.1-14 mm) to 16.1 g (8.1-11 mm) (Table 2). The interaction showed a best performance of 'Candongga' with all of the crown size (on average 17.8 g) (Fig. 4). Fruits also showed a differentiation about the qualitative aspects: the fruit solids soluble contents did not differ, with the exception of February when 'Nora' gave fruit with the lowest sugar content (8.1 °Brix) (Table 3). The interaction was statistically significant at the begin and at the end of the harvest period: in February the fruits of 'Candongga', especially these with small crown (6-8 mm), were more sweet (9.9 °Brix); on the contrary, the plants of 'Nora' with the same crown size produced fruits with the lowest sugar content (7.7 °Brix). In April the plants of 'Candongga' with medium crown (8.1-11 mm) gave the best fruits with the highest sweetness (9.8 °Brix) while plants of the same cultivar but with large crown produced fruits with the lowest sugar content (8.5 °Brix) (Fig. 5). Differences more remarkable were observed for the flesh hardness: during the first period of picking no differences were found regarding the crown size while, among the cultivars, 'Candongga' gave the best results (779.1 g) (Table 3), especially when plants with big crown were used (833.3 g; Fig. 6). In March, the two cultivars showed a similar flesh fruit hardness (on average 496.7 g) while, regarding the crown size, the smallest plants (6-8 mm) produced fruit with a flesh hardness of 539.7 g. The lowest result was observed with medium plants of 'Candongga' (346.7 g) (Fig. 6). At the end of the harvest period, 'Candongga' and the plants with big crown kept high value of hardness (respectively 629.9 and 586.3 g). In April, the plant of 'Candongga' with a crown size of 11.1-14 mm gave fruits with the highest flesh hardness (696.7 g) (Fig. 6).

CONCLUSION

Strawberry crown is an extremely high source of carbohydrates (solubles and storage) and therefore it plays a relevant role during plant growth and fruit development (Macias-Rodriguez et al., 2002). It's presumably to believe that more is big the crown more is rich in reservoir of carbohydrates, but significant interactions were also found of stolon diameter and leaf numbers on initial crown diameter (Bish et al., 2003). But a choice directed only on crown size not always gives the best results: both the plant crown size and the cultivar are two fundamental aspects influencing the yield and the fruit quality, that have to be considered together. Between the tested cultivars, 'Candongga' was the most productive especially with big crown diameter, while the average fruit weight was not influenced by crown size but only by the cultivars; even in this case, 'Candongga'

produced fruit with the highest average weight above all at the beginning and at the end of the productive cycle. Also the qualitative aspects seem to be more dependent on the cultivars. In conclusion, strawberry yield and quality are highly influenced by a combination of several factors such genotype, crown size, but even geoclimatic, agricultural techniques and plant typology; so, considering only the crown diameter as the basis for good production would be an over mistake.

Literature Cited

- Bish, E.B., Cantliffe, D.J. and Chandler, C.K. 2003. Plantlet size affects growth and development of strawberry plug transplants. Proc. Fla. State Hort. Soc. 116:105-107.
- Chercuitte, L., Sullivan, Y.A., Desjardins, Y.D. and Bedard, R. 1991. Yield potential and vegetative growth of summer-planted strawberry. Journal of the American Society for Horticultural Science 116:930-936.
- D'Anna, F., Moncada, A., Prinzivalli, C. and Caracciolo, G. 2007. Sicilia: meglio usare le piante fresche ma dipende dalla varietà impiegata. Rivista di Frutticoltura e di ortofloricoltura 4:26-33.
- Hennion, B., Scupp, J. and Longuessere, J. 1997. 'Fraisimotte®': a strawberry plug plant developed by CIREF in France. Acta Hort. 439:469-474.
- Jemmali, A. and Boxus, P. 1993. Early estimation of strawberry floral intensity and its improvement under cold greenhouse. Acta Hort. 348:357-360.
- Johnson, C., Raiford, T. and Whitley, K. 2005. Initial crown diameter of transplants influences marketable yield components of two strawberry cultivars in annual production system. International Journal of Fruit Science 5:23-29.
- Le Mière, P., Hadley, P., Darby, J. and Battey, N. 1998. The effect of thermal environment, planting date and crown size on growth, development and yield of *Fragaria x ananassa* Duch. cv Elsanta. J. Hort. Sci. Biotechnol. 73:786-795.
- Maas, J. 1986. Photoperiod and temperature effects on starch accumulation in strawberry roots. Adv. Strawberry Prod. 5:22-24.
- Macias-Rodriguez, L., Quero, E. and López, M.G. 2002. Carbohydrate differences in strawberry crowns and fruit (*Fragaria x ananassa*) during plant development. Agric. Food Chem. 50:3317-3321.
- Mason, D.T. 1987. Effect of initial plant size on the growth and cropping of strawberry (*Fragaria x ananassa* Duch.). Crop Res. (Hort. Res.) 27:31-47.
- Moncada, A., Caracciolo, G., Prinzivalli, C., Vetrano, F. and D'Anna, F. 2009. Effetti dell'epoca di trapianto di piante fresche a radice nuda di fragole prodotte in Sicilia. VII Convegno nazionale 'La fragola: presente e futuro', Marsala (TP) 25-27 febbraio.
- Popenoe, J. and Swartz, H.J. 1985. Yield component comparison of strawberry plants grown in various cultural systems. Adv. Strawberry Prod. 4:10-14.
- Wang, S. and Camp, M. 2000. Temperatures after bloom affect plant growth and fruit quality of strawberry. Sci. Hort. 85:183-199.

and total fruit production as affected by cultivars and crown size.

	February	March	April	May	Total Yield
	77,4 a	111,3 a	226,2 a	170,9 a	586,8 a
	88,2 a	125,6 a	209,2 a	143,1 b	567,9 a
	75,3 b	116,5 a	212,0 a	147,3 b	551,5 b
	87,6 a	126,9 a	79,9 a	154,8 b	592,1 a
	85,5 a	112,0 a	81,2 a	168,9 a	588,5 a
	*	*	*	*	*

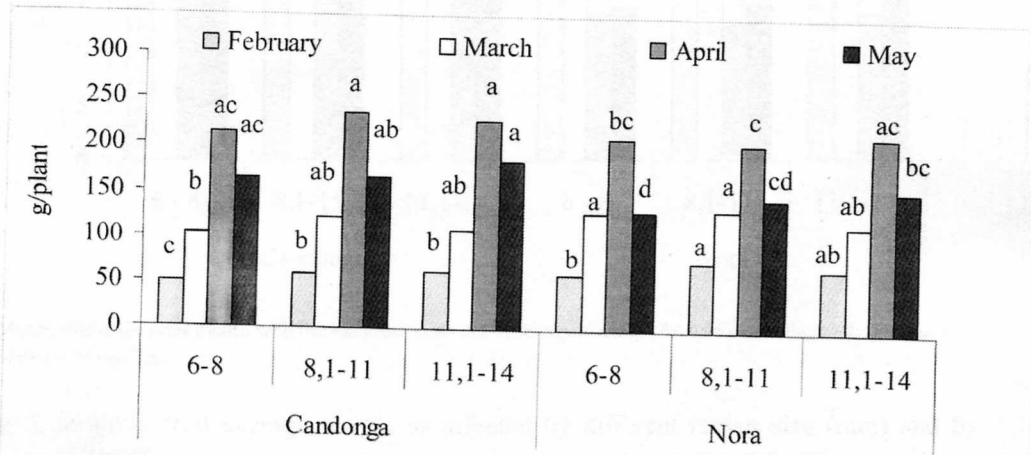
the same letter are not significantly different at 5% level (DMRT).

average weight as affected by cultivars and crown size.

	February	March	April	May	General fruit average weight
	14,9 a	17,0 a	17,4 a	18,6 a	16,6 a
	17,0 b	15,8 a	13,0 b	14,4 b	14,7 b
	16,2 a	16,9 a	15,5 a	15,7 a	15,7 ab
	16,1 a	16,4 a	15,0 a	17,7 a	16,1 a
	18,1 a	16,0 a	15,2 a	16,1 a	15,2 b
	n.s.	n.s.	*	*	

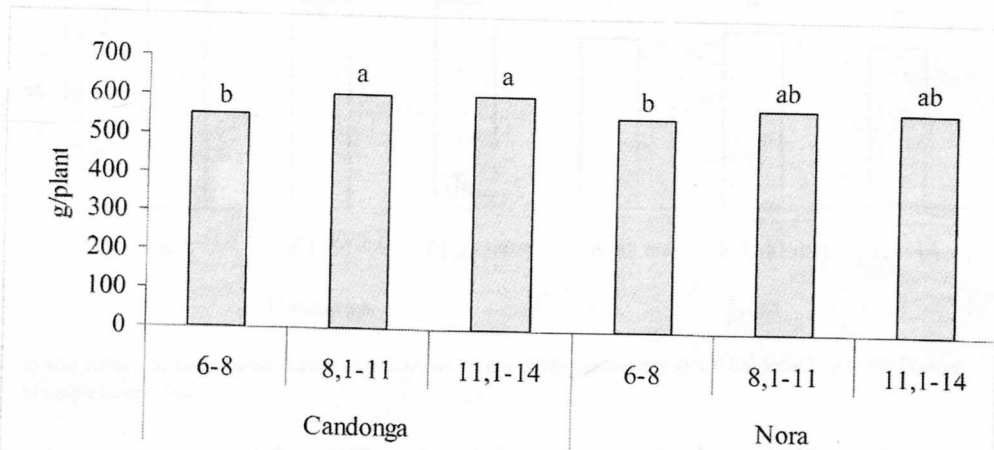
the same letter are not significantly different at 5% level (DMRT).

Figures



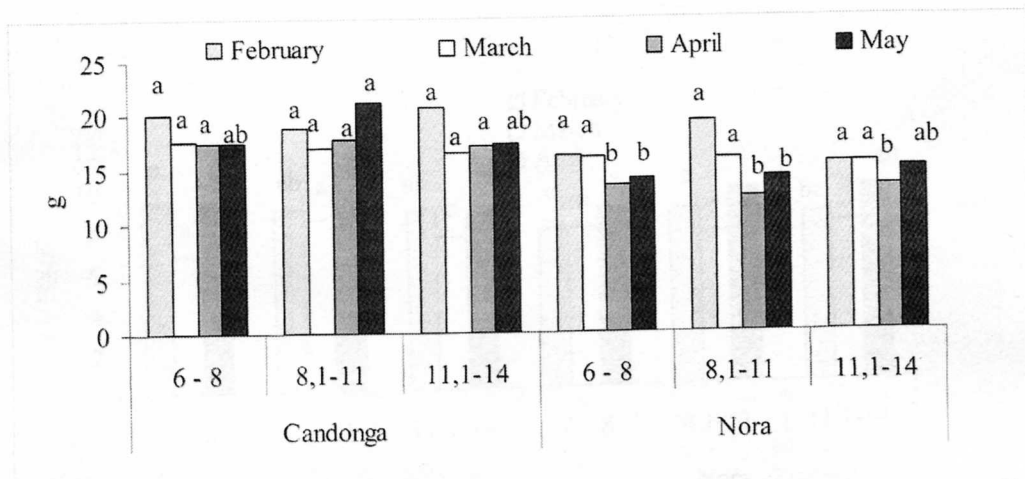
Means within the same month with the same letters do not differ significantly ($P < 0.05$) according to the Duncan's Multiple Range Test

Fig. 1. Monthly strawberry yield as affected by different crown size (mm) and by cultivars.



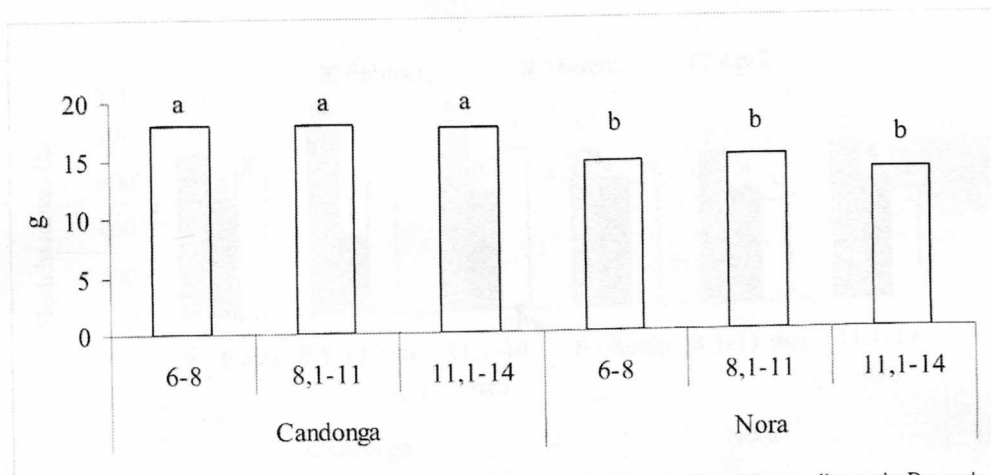
Means within the same month with the same letters do not differ significantly ($P < 0.05$) according to the Duncan's Multiple Range Test

Fig. 2. Total yield as affected by different crown size (mm) and by cultivars.



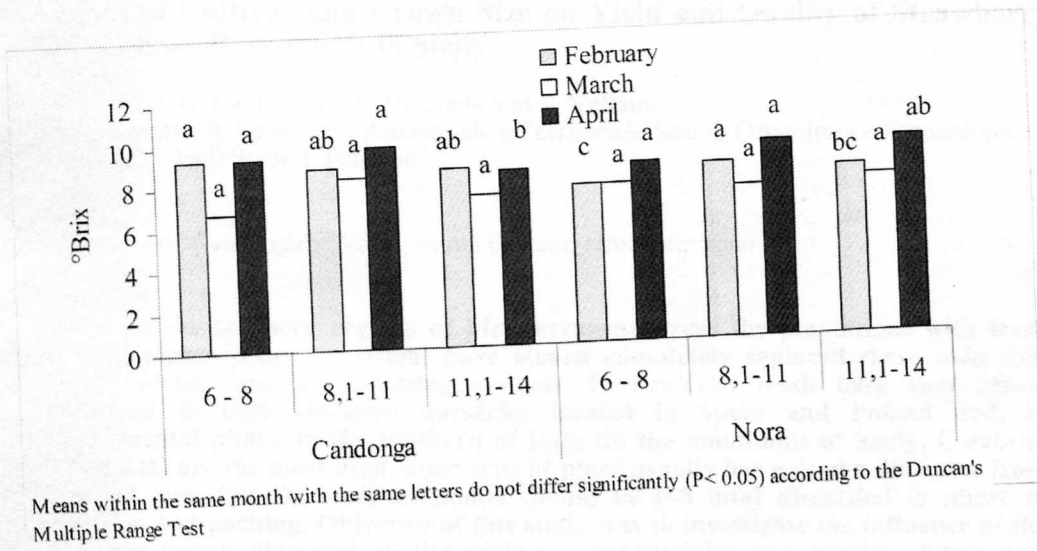
Means within the same month with the same letters do not differ significantly ($P < 0.05$) according to the Duncan's Multiple Range Test

Fig. 3. Monthly fruit average weight as affected by different crown size (mm) and by cultivars.



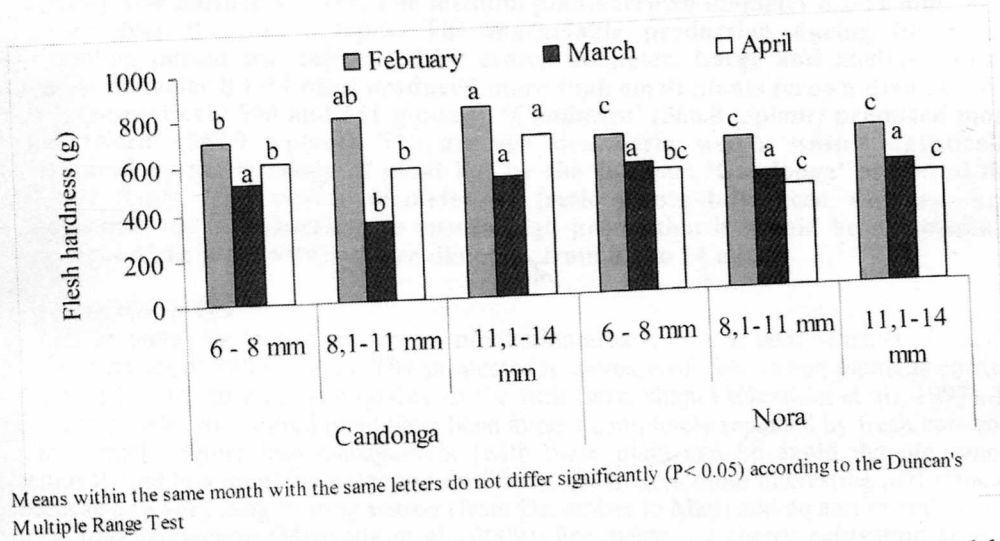
Means within the same month with the same letters do not differ significantly ($P < 0.05$) according to the Duncan's Multiple Range Test

Fig. 4. Fruit average weight as affected by different crown size (mm) and by cultivars.



Means within the same month with the same letters do not differ significantly ($P < 0.05$) according to the Duncan's Multiple Range Test

Fig. 5. Monthly fruit solid soluble contents as affected by different crown size (mm) and by cultivars.



Means within the same month with the same letters do not differ significantly ($P < 0.05$) according to the Duncan's Multiple Range Test

Fig. 6. Monthly fruit flesh hardness as affected by different crown size (mm) and by cultivars.

Use
Garc
Ch. L.
Unive
Schoc
Depar
Volos
Greec
Keyw
Abstr
shap
to ph
on qu
sum
area
shad
alrea
Garc
gree
deve
meas
nets
cond
shad
unde
grov
of th
INT
whit
high
defo
culti
deca
envi
adv
diff
This
pho
spec
and
con
inte
pot
MA
cor
wh
Pro
Ed
Ac