Middle East Journal of Agriculture Research
ISSN 2077-4605
Volume : 06 | Issue : 04 | Oct.-Dec. | 2017
Pages:1346-1358

Trend of vegetative growth and fruiting of some peach cultivars budded on Okinawa and Nemaguard rootstocks

Emadeldin A. H. Ahmed[1]; Salwa El-Habashy[1] and Mahmoud F. Maklad[2]

[1]Breeding Research Department of Fruit Trees, Ornamental and Woody Plants, Horticulture Research Institute, Agricultural Research Center, Giza, Egypt.
[2]Department of Horticulture, Faculty of Agriculture, Ain shams University, Cairo, Egypt.

Received: 06 Nov. 2017 / Accepted: 23 Dec. 2017 / Publication date: 28 Dec. 2017

ABSTRACT

This investigation was carried out during three successive seasons of 2014, 2015 and 2016 on three peach cultivars "Florda Prince, Early Swelling and Swelling" budded on two rootstocks Okinawa and Nemaguard to study the effect of these two rootstocks on growth, fruiting and yield. All trees were three years old, grown in sandy soil under drip irrigation system at private orchard located in, El-Bostan region, Behira Governorate, Egypt. Results showed that, Okinawa, induced bloom, vegetative bud burst, reaching its peak of bloom and maturity earlier than Nemaguard. While, Nemaguard delay the flowering duration (5 to 7 days) of all peach scions than Okinawa.

Trees budded on Nemaguard scored the highest significant values of number of shoots, Avg. leaf area, tree size, TCSA, number of fruits and total yield per tree as compared with Okinawa. Scions budded on Okinawa achieved the best values of Avg. shoot length; initial and final fruit set percentages than scions budded on Nemaguard without significant differences. On the other hand, fruit development period (FDP), harvest period, yield efficiency and most of fruit quality measurements did not influenced by both rootstocks.

Key words: Peach, Cultivars, Rootstocks, Okinawa, Nemaguard, Florda Prince, Early Swelling, Swelling, Yield efficiency.

Introduction

Peach is a popular fruit and considered as one of the important fruits in the world. In Egypt, most peach orchards planted with some low-chilling foreign introduced cultivars during the last thirty years by the Agricultural Research Projects or by the private sector. These cultivars were early, mid or late season with a good fruit characteristics and had been adapted to our local conditions such as Florda Prince, Desert Red, Tropic Snow, Tropic Sweet and Rhodes "Swelling" (Shaltout, 2003). According to the FAO statistical data in year 2016, the total harvested area of peaches reached 48986 Feddans (one feddan= 0.42ha) with total production of about 266628 tons. (FAOSTAT, 2016).

Rootstocks play a major role in modern orchards. The most important agricultural traits of the tree as a biotic unit, such as vigor, blossom initiation, fruit set, fruit size and fruit flavor, etc., may be, substantially, influenced by the rootstock (Tubbs, 1974; Dozier *et al.,* 1984). Physical and biotic environments in which rootstock abide are quite different from those for scion cultivars. Therefore, rootstocks became a cultural tool for peach growers to increase productivity and improve efficiency via better tree survival, controlled tree vigor, tolerate different biotic and abiotic stresses, increased fruit size, yield and quality (Reighard and Loreti, 2008). Thus, the choice of appropriate rootstock becomes economically important as the scion cultivar and its improvement required as much more time and more resources as scion cultivars breeding (Cummins and Aldwinckle, 1983; Scorza and Sherman, 1996).

Nemaguard rootstock is originated in Fort Valley, Georgia, by the U.S. Dept. Agr. Hort. Field Laboratory and introduced in 1961; a selected seedling from seeds obtained in 1949 from a commercial importer as *Prunus davidiana* Tree and fruit characters resemble peach *(P. Persica)*; it may be of hybrid origin *(P. persica* X *P. daviana)*. Percentage of seed germinations is high; 850 CU;

Corresponding Author: Emadeldin A. H. Ahmed, Breeding Research Department of Fruit Trees, Ornamental and Woody Plants, Horticulture Research Institute, Agricultural Research Center, Giza, Egypt. E-mail: emado13@hotmail.com

compatible with various peach varieties, showing very satisfactory growth, with good fruit yield; resistance to root knot nematode species. (Brooks and Almo, 1961).

Okinawa rootstock *(P. persica)* is originated in Gainesville, Florida from an imported seeds from Japan and it was taken to the United States in 1953 where it was selected as rootstock from seeds. Its chilling requirement is low (150 CU), used as source for breeding in adaptation a low- chill peach cultivar, resistance to *Meloidgyne incognita*, *M. javanica* and tolerant to *M. floridensis*. (Brooks and Almo, 1972).

Root-knot nematode is a major problem and can limit expansion of peach growing in different areas. In Egypt, the most widely used is Nemaguard as a rootstock for peaches, where its seeds are imported yearly from U.S.A. or Italy which coast more expenditures of dollars yearly while, Okinawa is sometimes used because of its low chilling requirements, nematode resistant and easily produced under our local conditions.

The aim of this study was to investigate the effect of Okinawa and Nemaguard rootstocks on growth, fruiting and yield of three peach cultivars namely "Florda Prince, Early Swelling and Rhodes (Swelling)".

Materials and Methods

In this study, the field experiment was carried out during the three successive seasons of 2014, 2015 and 2016, in a private orchard, El-Bostan, Behira Governorate, Egypt. Trees were three years old grown in sandy soil at 4 X 5 meters apart under drip irrigation system. All trees subjected to the same cultural practices, disease and pest control programs.

Studied characteristics:

Flowering parameters:

Date of the beginning of flowering was recorded when the first flower appeared. Date of vegetative buds opening was recorded when buds showed the first sign of opening (bud burst). Full and end of blooming, flowering duration, initial fruit set percentage (determined after 21 days of full bloom), final fruit set percentage, fruit drop percent, Fruit developing period (FDP- days from full bloom to maturity), date of maturity and harvest period were recorded. These data were determined in five replicates (each replicate contained five branches) and flowering duration (no. of days) was recorded.

Vegetative growth, yield and fruit quality parameters:

Data of vegetative parameters were recorded at the end of growing season (November) such as [no. of shoots /season, avg. shoot length (cm), avg. leaf area (cm^2) and trunk circumference (measured 10 cm above the union point)]. Besides, tree size (m^3) and trunk cross sectional area TCSA (cm^2) were calculated according to Westwood, (1988) as the following equations:
Tree size (volume of spheroid) = $4/3\ \pi\ ab^2$ ($\pi = 3.14$, a= 1/2 major axis and b= minor axis).
TCSA = $\pi\ r^2$ (($\pi = 3.14$, r = 1/2 diameter).

At harvest time, number of fruits per tree, total yield per tree (kg/tree) and yield efficiency (kg of fruits per cm^2 of TCSA) were recorded. Furthermore, fruit samples (20 fruits from each scion/rootstock combination) were picked at random to determine fruit physical and chemical characteristics. The fruit parameters including [Avg. fruit weight (g), volume (cm^3) fruit shape index (ratio of fruit length (L)/fruit diameter (D)), pit weight (g), flesh percentage (%), flesh thickness (cm), fruit firmness ($lb/inch^2$), soluble solid content SSC (Brix°), acidity (as titratable malic acid) and SSC/Acidity].

Statistical analysis:-

Experiment designed in completely randomized blocks with five trees (tree- as a replicate). The obtained data were subjected to analysis of variance (ANOVA). Duncan's multiple range test at 5%

level of significance (p=0.05) was used for means comparisons according to Gomez and Gomez, (1984).

Results and Discussion

Floral characteristics:

Data presented in table (1) showed the influence of Okinawa and Nemaguard rootstocks on some floral and fruiting characteristics including dates of beginning of bloom, vegetative buds opening, full and end of bloom, flowering duration, fruit development period (FDP), fruit maturity and harvest duration. It is clear that, Florda Prince, Early Swelling and Swelling budded on Okinawa were earlier in beginning of floral bud opening (first bloom) and vegetative buds opening (bud burst) about (1-6 days) than those budded on Nemaguard during the three seasons of study. Moreover, all cultivars budded on Okinawa reached their peak of bloom (full bloom) and maturity earlier than scions budded on Nemaguard about (5 to 9) days with Florda Prince and about (1 to 4) days with Early Swelling and Swelling during all seasons. While, Nemaguard delay the flowering duration of all peach scions than Okinawa (ranged between 5 to 7 days) with all cultivars during all seasons. On the other hand, fruit development period (FDP) and harvest period, did not affect by rootstocks. Regardless the effect of rootstocks, Florda Prince was the first cultivar in harvest followed by Early Swelling and the latest was "Swelling". Generally, harvest period ranged between one to two weeks with all scion/rootstock combinations. Shaltout, (1987) indicated that Florda Prince harvest period in Egypt ranged from 02/05 to 12/05 and 01/05 to 10/05 in 1986 and 1987 seasons, respectively. While, Swelling harvest period ranged from 18/06 to 30/06 and 20/06 to 30/06 in 1992 and 1993 seasons, respectively (Shaltout, 1995).

These results agreed with Barreto, *et al.* (2017) who stated that, peach trees grafted on Okinawa and Tsukuba rootstocks reached their peak of bloom seven days earlier than peach trees grafted on Nemaguard. Also, agreed with Abdel-Aziz *et al.* (1985) who revealed that, "Mit Ghamr" peach grafted on Okinawa started vegetative bud burst and bloom, reaching peak of bloom and peak of fruit set earlier than "Mit Ghamr" grafted on "Mit Ghamr" rootstock.

Table (2) showed the initial fruit set and final fruit set percentages, there were positive correlation between them. There were insignificant influence of rootstocks; Florda Prince was the best during all seasons followed by Early Swelling then Swelling in the first and third seasons with significant differences. While, in the second season there were insignificant differences. On the other hand, the highest fruit drop percentage was recorded for Swelling with insignificant differences during the first season, and with significant differences in the second seasons, respectively. While, Florda Prince scored the highest value without significance during the third season. In respect of rootstocks, scions budded on Okinawa achieved the best percentages of the initial and final fruit set than scions budded on Nemaguard without significant differences.

Vegetative characteristics:

Data in table (3) showed the number of shoots, average shoot length, Average leaf area and tree size during each season of study. The rootstock influence on the number of shoots per season during the three seasons. All cultivars scored the highest significant values of number of shoots per season when budded on Nemaguard comparing with those budded on Okinawa. Besides that, FlordaPrince was recorded the highest significant value of number of shoots during the three seasons of study.

Regarding the average shoot length, there were insignificant differences between the two rootstocks with all scions during all seasons. Swelling gave the highest values in the first and third seasons. While, in the second season, Early Swelling recorded the highest significant average shoot length.

The same previous trend was achieved with avg. leaf area and tree size characteristics. Nemaguard gave the highest values of both characters with all scions compared with Okinawa. In addition, Florda Prince recorded the highest significant values of tree size during all seasons. Regarding all scion/rootstock combinations, same trend obtained by Indreias, (2011) who found none significant differences concerning the "Redhaven" and "Springcrest" on five rootstocks combinations.

Table 1: Effect of Okinawa and Nemaguard rootstocks on floral and fruiting characteristics of three peach cultivars during 2014, 2015 and 2016 seasons

Parameter	Cultivars / Rootstocks	FlordaPrince			EarlySwelling			Swelling		
		1st season 2013 / 2014	2nd season 2014 / 2015	3rd season 2015 / 2016	1st season 2013 / 2014	2nd season 2014 / 2015	3rd season 2015 / 2016	1st season 2013 / 2014	2nd season 2014 / 2015	3rd season 2015 / 2016
Date of floral buds opening	Okinawa	16/ 12 /2013	20/ 12 /2014	18/ 12 /2015	21/ 01 /2014	26/ 01 /2015	28/ 01 /2016	22/ 02 /2014	25/ 02 /2015	29/ 02 /2016
	Nemaguard	20/ 12 /2013	23/ 12 /2014	22/ 12 /2015	25/ 01 /2014	29/ 01 /2015	01/ 02 /2016	27/ 02 /2014	02/ 03 /2015	02/ 03 /2016
Date of vegetative buds opening	Okinawa	30/ 12 /2013	08/ 01 /2015	12/ 01 /2016	27/ 01 /2014	05/ 02 /2015	08/ 02 /2016	26/ 02 /2014	28/ 02 /2015	04/ 03 /2016
	Nemaguard	02/ 01 /2014	14/ 01 /2015	15/ 01 /2016	02/ 02 /2014	09/ 02 /2015	11/ 02 /2016	04/ 03 /2014	06/ 03 /2015	05/ 03 /2016
Date of full bloom	Okinawa	25/ 01 /2014	23/ 01 /2015	05/ 02/2016	15/ 02 /2014	18/ 02 /2015	22/ 02 /2016	06/ 03 /2014	11/ 03 /2015	15/ 03 /2016
	Nemaguard	01/ 02 /2014	30/ 01 /2015	10/ 02 /2016	19/ 02 /2014	21/ 02 /2015	26/ 02 /2016	10/ 03 /2014	16/ 03 /2015	16/ 03 /2016
End of flowering	Okinawa	02/ 02 /2014	03/ 02 /2015	09/ 02 /2016	21/ 02 /2014	25/ 02 /2015	29/ 02 /2016	09/ 03 /2014	15/ 03 /2015	18/ 03 /2016
	Nemaguard	10/ 02 /2014	09/ 02 /2015	16/ 02 /2016	27/ 02 /2014	03/ 03 /2015	07/ 03 /2016	13/ 03 /2014	20/ 03 /2015	19/ 03 /2016
Flowering duration (days)	Okinawa	48	45	50	31	30	32	14	18	18
	Nemaguard	52	48	56	33	33	35	14	18	17
Fruit development period (days)	Okinawa	75-79	80-82	77-83	85-95	86-92	85-91	91-98	99-102	100-103
	Nemaguard	77-78	79-83	76-84	86-93	89-92	86-91	92-102	98-103	99-102
Date of maturity	Okinawa	10/ 04 /2014 to 22/ 04 /2014	13/ 04 /2015 to 26/ 04 /2015	22/ 04 /2016 to 02/ 05 /2016	11/ 05 /2014 to 26/ 05 /2014	15/ 05 /2015 to 28/ 05 /2015	17/ 05 /2016 to 30/ 05 /2016	05/ 06 /2014 to 15/ 06 /2014	18/ 06 /2015 to 25/ 06 /2015	19/ 06 /2016 to 27/ 06 /2016
	Nemaguard	15/ 04 /2014 to 29/ 04 /2014	19/ 04 /2015 to 03/ 05 /2015	26/ 04 /2016 to 10/ 05 /2016	16/ 05 /2014 to 31/ 05 /2014	21/ 05 /2015 to 03/ 05 /2015	22/ 05 /2016 to 05/ 06 /2016	10/ 06 /2014 to 23/ 06 /2014	22/ 06 /2015 to 01/ 07 /2015	24/ 06 /2016 to 02/ 07 /2016
Harvest period (days)	Okinawa	12	13	10	15	13	12	10	7	8
	Nemaguard	14	14	13	15	13	14	13	9	8

Table 2: Effect of Okinawa and Nemaguard rootstocks on initial fruit set, final fruit set and fruit drop percentages of three peach cultivars during 2014, 2015 and 2016 seasons

Cultivars / Rootstocks	Initial fruit set percentage				Final fruit set percentage				Fruit drop percentage			
	Florda Prince	Early Swelling	Swelling	Mean	Florda Prince	Early Swelling	Swelling	Mean	Florda Prince	Early Swelling	Swelling	Mean
1st season 2013/2014												
Okinawa	98.28 a	93.24 ab	89.50 bc	93.67 A'	81.21 a	69.19 b	67.81 b	72.74 A'	24.85 a	28.90 a	30.77 a	28.17 A'
Nemaguard	98.67 a	94.77 ab	87.46 c	93.63 A'	75.71 ab	71.41 b	69.09 b	72.07 A'	24.76 a	28.52 a	29.34 a	27.54 A'
Mean	98.48 A	94.00 B	88.48 C		78.46 A	70.30 B	68.45 B		24.81 A	28.71 A	30.06 A	
2nd season 2014/2015												
Okinawa	93.32 a	93.31 a	91.61 a	92.75 A'	72.40 ab	75.62 a	66.90 ab	71.46 A'	28.37 ab	24.43 b	33.52 a	28.77 A'
Nemaguard	94.34 a	93.34 a	89.79 a	92.49 A'	70.53 ab	73.78 a	63.81 b	69.38 A'	28.39 ab	30.83 ab	34.06 a	31.10 A'
Mean	93.83 A	93.32 A	90.70 A		71.47 A	74.70 A	65.36 B		28.38 B	27.63 B	33.79 A	
3rd season 2015/2016												
Okinawa	97.32 ab	97.05 ab	92.37 b	95.58 A'	76.17 a	78.59 a	77.45 a	77.41 A'	26.93 a	20.91 b	25.29 ab	24.38 A'
Nemaguard	98.50 a	94.60 ab	91.68 b	94.93 A'	76.26 a	76.18 a	73.26 a	75.24 A'	25.60 ab	25.75 ab	24.56 ab	25.30 A'
Mean	97.91 A	95.82 A	92.02 B		76.22 A	77.38 A	75.36 A		26.26 A	23.33 A	24.92 A	

Means with the same letter in each column are statistically insignificant at 5 % level of Duncan's multiple range tests.

Table 3: Effect of Okinawa and Nemaguard rootstocks on No. of shoots /season, Avg. shoot length, Avg. leaf area and tree size of three peach cultivars during 2014, 2015 and 2016 seasons

Cultivars / Rootstocks	No. of shoots / season				Avg. shoot length (cm)				Avg. leaf area (cm^2)				Tree size (m^3)			
	Florda Prince	Early Swelling	Swelling	Mean	Florda Prince	Early Swelling	Swelling	Mean	Florda Prince	Early Swelling	Swelling	Mean	Florda Prince	Early Swelling	Swelling	Mean
1st season 2013/2014																
Okinawa	1489 b	1050 d	953.4 e	1164.13 B'	33.94 b	35.13 b	39.09 a	36.32 A'	33.02 c	38.34 b	40.01 ab	37.12 B'	25.39 d	30.65 a-c	27.99 cd	28.01 B'
Nemaguard	1590 a	1202 c	1023 de	1271.66 A'	34.64 b	35.75 ab	35.82 ab	35.40 A'	34.69 c	41.78 a	42.20 a	39.56 A'	33.67 a	31.80 ab	30.01 bc	31.83 A'
Mean	1539 A	1126 B	988.2 C		34.29 B	35.44 AB	37.45 A		33.86 B	40.06 A	41.10 A		29.53 A	31.23 A	29.00 A	
2nd season 2014/2015																
Okinawa	1829 b	1316 d	1094 e	1413 B'	31.98 bc	35.56 a	32.42 bc	33.32 A'	41.53 d	42.32 cd	46.20 ab	43.35 B'	34.57 bc	34.78 bc	32.34 c	33.90 B'
Nemaguard	1938 a	1430 c	1143 e	1504 A'	31.72 c	34.71 ab	31.07 c	32.50 A'	44.45 bc	45.23 b	48.75 a	46.14 A'	36.82 ab	38.17 a	35.94 ab	36.97 A'
Mean	1884 A	1373 B	1118 C		31.85 B	35.13 A	31.75 B		42.99 B	43.78 B	47.47 a		35.69 AB	36.47 A	34.14 B	
3rd season 2015/2016																
Okinawa	2004 a	1520 b	1227 d	1584 B'	37.96 ab	38.76	40.22 a	38.98 A'	49.08 c	49.56 c	54.61 ab	51.08 B'	40.40 c	41.44 bc	42.72 ab	41.52 B'
Nemaguard	2086 a	1580 b	1336 c	1667 A'	38.49 ab	37.56 b	38.18 ab	38.08 A'	52.50 bc	53.34 a-c	57.73 a	54.52 A'	43.89 a	43.34 ab	43.43 ab	43.55 A'
Mean	2045 A	1550 B	1282 C		38.22 A	38.16 A	39.22 A		50.79 B	51.45 B	56.17 A		42.14 A	42.39 A	43.08 A	

Means with the same letter in each column are statistically insignificant at 5 % level of Duncan's multiple range tests.

Table (4) showed the effect of rootstock on TCSA (Trunk cross sectional area). Nemaguard was significantly higher than Okinawa. In addition, Swelling and Early Swelling were higher than Florda Prince during first and third seasons. Concerning number of fruits and total yield per tree, Florda Prince budded on Nemaguard, was the best as compared with "Early Swelling" and Swelling.

Barreto, *et al.,* (2017) stated that, the largest trunk diameters were observed on Florda guard and Nemaguard without statistically difference from Okinawa. Moreover, Indreias, (2011) stated that, Trunk cross sectional areas with "Springcrest" were larger than those with "Redhaven" while, among rootstocks, "Tomis 28" induced the smallest TCSA for both cultivars.

Furthermore, there were insignificant influence of rootstocks on yield efficiency. Florda Prince scored the highest significant values during the three seasons; except, in the second season without significance with Early Swelling.

These results are in line with Barreto, *et al.,* (2017) who revealed that, productivity of "Chimarrita" peach trees was higher on Tsukuba, Flordaguard and Nemaguard rootstocks with no significant difference with Chimarrita trees on Okinawa.

Fruit quality

Data in tables (5, 6 and 7) showed the results of fruit quality parameters of different peach scions budded on two rootstocks. The two rootstocks showed non-significant differences with all scions during the three seasons. Concerning the cultivars, Swelling had the highest values of most fruit quality characters (fruit weight, avg. fruit volume, avg. fruit height, avg. fruit diameter, flesh thickness, avg. Pit weight and flesh percentage) especially in the first and second seasons, except the fruit firmness parameter, Florda Prince recorded the highest significant values followed by Early Swelling during all seasons of study.

Table (8) showed the chemical properties of fruits of all cultivars budded on Okinawa and Nemaguard rootstocks. In the respect of cultivars, Swelling scored the highest significant values of SSC (soluble solid contents) and lowest significant values of acidity percentage. While, FlordaPrince had the lowest significant values of SSC/acidity ratio in comparing with other cultivars.

These results are in harmony with Giorgi *et al.,* (2005) who found that, firmness, soluble solid contents (SSC) and titratable acidity of "Suncrest" peach fruits did not affect by rootstocks.

Moreover, Wongtanet and Boonprakob (2010) revealed that, Okinawa had the highest growth and good scion performance as compared with other rootstocks (either the local rootstocks "White Angkhang, Red Angkhang and Khunwang" or the foreign rootstocks such as "Costal peach, Flordaguard and Premier").

In conclusion, despite of the difference between the two peach rootstocks in their chilling requirements [Okinawa 150 CU & Nemaguard 850 CU], the performance of peach scions were better on Nemaguard but with insignificant differences in many characteristics as compared with those on Okinawa. Morover, peach cultivars budded on Okinawa started bloom, vegetative bud burst, reaching its peak of bloom and maturity earlier than those on Nemaguard. While, Nemaguard delay the flowering duration (5 to 7 days) of all peach scions than Okinawa. On the other hand, fruit development period (FDP), harvest period, yield efficiency and most of fruit quality measurements did not influenced by both rootstocks.

So, it is recommended to expand the usage of Okinawa as a rootstock for peaches beside Nemagaurd.

Table 4: Effect of Okinawa and Nemaguard rootstocks on TCSA, number of fruits per tree, yield per tree and yield efficiency of three peach cultivars during 2014, 2015 and 2016 seasons

Cultivars / Rootstocks	TCSA (cm^2)				No. of fruits/tree				Yield /tree (Kg)				Yield efficiency			
	Florda Prince	Early Swelling	Swelling	Mean	Florda Prince	Early Swelling	Swelling	Mean	Florda Prince	Early Swelling	Swelling	Mean	Florda Prince	Early Swelling	Swelling	Mean
1st season 2013/2014																
Okinawa	71.72 d	82.06 c	86.77 bc	80.18 B'	171.4 b	141.0 c	78.60 d	130.30 B'	16.40 c	14.73 d	8.416 f	13.18 B'	0.2302 a	0.180 b	0.096 c	0.1687 A'
Nemaguard	93.57 ab	95.44 ab	97.03 a	95.35 A'	195.4 a	173.2 b	89.80 d	152.80 A'	18.84 a	17.47 b	9.572 e	15.30 A'	0.2024 ab	0.184 b	0.1018 c	0.1627 A'
Mean	82.64 B	88.75 AB	91.90 A		183.4 A	157.1 B	84.20 C		17.62 A	16.10 B	8.994 C		0.2163 A	0.182 B	0.098 C	
2nd season 2014/2015																
Okinawa	101.90 c	109.00 bc	117.70 b	109.50 B'	208.80 b	218.40 b	105.80 c	177.70 B'	22.57 a	22.18 a	12.48 b	19.08 A'	0.2208 a	0.2074 a	0.1112 b	0.1798 A'
Nemaguard	121.30 b	122.50 b	137.30 a	127.00 A'	232.40 a	236.40 a	116.00 c	194.90 A'	24.75 a	23.92 a	13.50 b	20.72 A'	0.2060 a	0.1980 a	0.1020 b	0.1687 A'
Mean	111.60 B	115.70 B	127.50 A		220.60 A	227.40 A	110.90 B		23.66 A	23.05 A	12.99 B		0.2134 A	0.2027 A	0.1066 B	
3rd season 2015/2016																
Okinawa	150.00 c	165.50 c	158.30 c	158.00 B'	280.40 c	288.80 bc	211.60 d	260.30 B'	37.69 a	34.54 b	24.21 d	32.15 B'	0.2498 a	0.2136 ab	0.1544 c	0.2059 A'
Nemaguard	168.50 bc	193.40 a	184.20 ab	182.00 A'	316.20 a	304.00 ab	223.80 d	281.30 A'	38.74 a	35.26 b	26.70 c	33.57 A'	0.2260 a	0.1800 bc	0.1460 c	0.1840 A'
Mean	159.30 B	179.50 A	171.30 AB		298.30 A	296.40 A	217.70 B		38.22 A	34.90 b	25.45 C		0.2379 A	0.1968 B	0.1502 c	

Means with the same letter in each column are statistically insignificant at 5 % level of Duncan's multiple range tests.

Table 5: Effect of Okinawa and Nemaguard rootstocks on Avg. fruit weight, Avg. fruit volume and fruit firmness of three peach cultivars during 2014, 2015 and 2016 seasons

Cultivars / Rootstocks	Avg. fruit weight (g)				Avg. fruit volume (cm^3)				Fruit firmness (Lb/ $inch^2$)			
	Florda Prince	Early Swelling	Swelling	Mean	Florda Prince	Early Swelling	Swelling	Mean	Florda Prince	Early Swelling	Swelling	Mean
1st season 2013/2014												
Okinawa	95.80 b	107.00 a	107.50 a	103.40 A'	102.00 ab	113.40 a	109.40 ab	108.30 A'	9.30 a	6.834 a	5.51 c	7.21 A'
Nemaguard	96.46 b	101.30 ab	107.30 a	101.70 A'	97.80 b	104.80 ab	108.00 ab	103.50 A'	8.914 a	6.984 b	5.82 c	7.23 A'
Mean	96.13 B	104.20 A	107.40 A		99.90 B	109.10 A	108.70 A		9.107 A	6.909 B	5.66 C	
2nd season 2014/2015												
Okinawa	109.20 a	103.00 a	118.40 a	110.20 A'	106.40 a	103.80 a	121.20 a	110.50 A'	8.55 a	7.01 b	5.10 c	6.88 A'
Nemaguard	106.90 a	101.20 a	117.50 a	108.50 A'	102.80 a	104.60 a	118.40 a	108.60 A'	9.06 a	7.10 b	5.24 c	7.13 A'
Mean	108.00 A	102.10 B	118.00 A		104.60 B	104.20 B	119.80 A		8.81 A	7.055 B	5.17 C	
3rd season 2015/2016												
Okinawa	134.80 a	120.00 bc	114.30 c	123.10 A'	139.00 a	125.80 bc	118.80 c	127.90 A'	9.42 a	7.47 b	5.44 c	7. 45 A'
Nemaguard	125.30 b	116.40 bc	118.70 bc	120.10 A'	129.20 b	122.00 bc	125.60 bc	125.60 A'	9.28 a	7.44 b	5.26 c	7.33 A'
Mean	130.10 A	118.20 B	116.50 B		134.10 A	123.90 B	122.20 B		9.35 A	7.45 B	5.35 C	

Means with the same letter in each column are statistically insignificant at 5 % level of Duncan's multiple range tests.

Table 6: Effect of Okinawa and Nemaguard rootstocks on Avg. fruit height, Avg. fruit diameter and fruit shape index fruit firmness of three peach cultivars during 2014, 2015 and 2016 seasons

Cultivars	Avg. fruit height (L) (cm)				Avg. fruit diameter (D) (cm)				Fruit shape index (Avg. L/D ratio)			
	Florda Prince	Early Swelling	Swelling	Mean	Florda Prince	Early Swelling	Swelling	Mean	Florda Prince	Early Swelling	Swelling	Mean
1st season 2013/2014												
Okinawa	5.66 a	5.70 a	5.68 a	5.68 A'	5.72 a	5.86 a	5.90 a	5.827 A'	0.992 a	0.964 a	0.960 a	0.972 A'
Nemaguard	5.48 a	5.72 a	5.66 a	5.62 A'	5.66 a	5.90 a	5.24 a	5.60 A'	0.966 a	0.970 a	0.956 a	0.964 A'
Mean	5.57 A	5.71 A	5.67 A		5.69 A	5.88 A	5.57 A		0.979 A	0.967 A	0.958 A	
2nd season 2014/2015												
Okinawa	5.40 b	5.74 ab	5.70 ab	5.68 A'	5.66 b	5.84 ab	6.16 a	5.887 A'	0.952 a	0.986 a	0.910 a	0.9493 A'
Nemaguard	5.64 ab	5.94 a	6.04 a	5.81 A'	5.88 ab	5.88 ab	6.10 a	5.953 A'	0.973 a	0.956 a	0.986 a	0.9716 A'
Mean	5.57 B	5.67 B	5.99 A		5.77 B	5.86 B	6.13 A		0.962 A	0.971 A	0.948 A	
3rd season 2015/2016												
Okinawa	6.12 b	6.10 b	6.20 b	6.14 A'	6.30 a	6.22 a	6.22 a	6.247 A'	0.984 a	0.982 a	0.990 a	0.985 A'
Nemaguard	6.10 b	6.08 b	6.46 a	6.213 A'	6.20 a	6.26 a	6.38 a	6.28 A'	0.9826 a	0.966 a	1.013 a	0.987 A'
Mean	6.11 B	6.090 B	6.33 A		6.25 A	6.24 A	6.30 A		0.983 A	0.974 A	1.001 A	

Means with the same letter in each column are statistically insignificant at 5 % level of Duncan's multiple range tests.

Table 7: Effect of Okinawa and Nemaguard rootstocks on flesh percentage, Avg. pit weight, and flesh percentage of three peach cultivars during 2014, 2015 and 2016.

Cultivars / Rootstocks	Flesh thickness (cm)				Avg. pit weight (g)				Flesh percentage (%)			
	Florda Prince	Early Swelling	Swelling	Mean	Florda Prince	Early Swelling	Swelling	Mean	Florda Prince	Early Swelling	Swelling	Mean
1st season 2013/2014												
Okinawa	2.00 a	2.10 a	2.04 a	2.47 A	5.038 ab	5.00 ab	5.542 a	5.193 A	94.73 a	95.19 a	94.87 a	94.93 A
Nemaguard	2.00 a	2.03 a	2.04 a	2.023 A	5.106 ab	4.704 b	5.136 ab	4.98 A	95.21 a	95.30 a	95.17 a	95.22 A
Mean	2.00 A	2.065 A	2.04 A		5.07 AB	4.85 B	5.339 A		94.97 A	95.24 A	95.02 A	
2nd season 2014/2015												
Okinawa	1.86 a	2.03 a	2.00 a	1.963 A	5.22 ab	5.198 ab	5.646 a	5.355 A	94.66 b	94.66 b	94.88 ab	94.74 B
Nemaguard	1.84 a	2.08 a	2.08 a	2.00 A	4.90 b	4.804 b	5.338 ab	5.014 A	95.07 ab	95.26 ab	95.70 a	95.34 A
Mean	1.85 A	2.055 A	2.04 A		5.06 B	5.001 B	5.492 A		94.86 A	94.96 A	95.29 A	
3rd season 2015/2016												
Okinawa	2.16 a	2.08 ab	2.04 b	2.093 A	6.20 a	5.74 a	5.62 a	5.854 A	95.39 a	95.18 ab	95.08 ab	95.22 A
Nemaguard	2.15 a	2.10 ab	2.02 b	2.090 A	5.88 a	5.67 a	5.95 a	5.841 A	95.28 ab	95.26 ab	94.97 b	95.17 A
Mean	2.155 A	2.090 AB	2.030 B		6.04 A	5.707 A	5.794 A		95.34 A	95.22 AB	95.02 B	

Means with the same letter in each column are statistically insignificant at 5 % level of Duncan's multiple range tests.

Table 8: Effect of Okinawa and Nemaguard rootstocks on fruit chemical properties (SSC, acidity percentage and SSC/acidity ratio) of three peach cultivars during 2014, 2015 and 2016.

Cultivars / Rootstocks	SSC (Brix°)				Acidity (%)				SSC / acidity ratio			
	Florda Prince	Early Swelling	Swelling	Mean	Florda Prince	Early Swelling	Swelling	Mean	Florda Prince	Early Swelling	Swelling	Mean
1st season 2013/2014												
Okinawa	10.26 c	12.23 b	15.24 a	12.58 A	0.562 a	0.259 b	0.154 d	0.325 A	19.29 e	44.74 d	96.87 a	53.64 A
Nemaguard	10.54 c	12.34 b	14.28 a	12.39 A	0.578 a	0.207 c	0.18 cd	0.321 A	18.17 e	59.69 c	81.07 b	52.98 A
Mean	10.40 C	12.29 b	14.76 A		0.570 A	0.233 B	0.167 C		18.73 C	52.22 B	88.97 A	
2nd season 2014/2015												
Okinawa	10.53 d	13.00 c	15.53 a	13.02 A	0.629 a	0.230 b	0.208 b	0.3557 A	17.72 d	57.11 c	77.81 ab	50.88 A
Nemaguard	9.91 d	12.80 c	14.17 b	12.29 B	0.624 a	0.186 b	0.182 b	0.3307 A	15.94 d	68.21 b	80.97 a	55.04 A
Mean	10.22 C	12.90 B	14.85 A		0.6265 A	0.2080 B	0.195 B		16.83 C	62.66 B	79.39 A	
3rd season 2015/2016												
Okinawa	10.58 c	12.52 b	15.08 a	12.73 A	0.614 a	0.203 b	0.169 b	0.328 A	16.56 c	62.62 b	89.73 a	56.31 A
Nemaguard	10.52 c	12.54 b	15.14 a	12.73 A	0.582 a	0.200 b	0.160 b	0.314 A	17.95 c	62.94 b	95.31 a	58.73 A
Mean	10.55 C	12.53 B	15.11 A		0.598 A	0.2016 B	0.1648 C		17.26 C	62.78 B	92.52 A	

Means with the same letter in each column are statistically insignificant at 5 % level of Duncan's multiple range tests.

References

Abdel-Aziz, E. B., M. Khalil and A. Yousry, 1985. Tree development, yield and fruit quality of Mit-ghamr peach on two rootstocks. Agricultural Research Review, 63 (3):81-85.

Barreto, C. F., M. B. M. Kirinus, P. S. Silva, S. B. Andrade, C. V. Rombaldi, M. B. Malgarim and J. C. Fachinello, 2017. Growth, yield and fruit quality of "Chimarrita" Peach trees grafted on different rootstocks. African Journal of agricultural Research. Vol. 12(39): 2933-2939.

Brooks, R.M. and H.P. Olmo, 1961. Register of new fruit and nut varieties. Nemaguard peach. Proc. Amer. Soc. Hort. Sci. 78: 634-635.

Brooks, R.M. and H.P. Olmo, 1972. Register of new fruit and nut varieties, Second Edition. Univ. of California Press, Berkely.

Cummins, J.N. and H.S. Aldwinckle, 1983. Rootstock breeding. In methods in fruit breeding. (Ed.) by J.N. Moore and Janick. Purdue University Press, West Lafayette, Ind. pp. 294-327.

Dozier, W.A.; J.W. Knowles and C.C. Carlton, 1984. Survival growth and yield of peach trees as affected by rootstocks. Hortscience, 19: 26-30.

FAO, 2016. Food and Agriculture Organization. (http:// faostat. Fao.org).

Giorge, M., F. Capocasa, J. Scalzo, G. Murri, M. Battino and B. Mezzeti, 2005. The rootstock effect on plant adaptability, production, fruit quality, and nutrition in the peach (cv. Suncrest). Scientia Horticulturae. 107(1):36-42.

Gomez, K. A. and A. A. Gomez, 1984. Statistical Procedures for Agricultural Research, second edition. John Wiley, New York, USA.

Indreias, A., 2011. Interaction between rootstock and scion growth and productivity of peach. Acta Horticulturae. 903:507-511.

Reighard, G. L. and F. Loreti, 2008. Chapter 8: Rootstock Development. In: D. R. Layne and D. Bassi (eds) The peach: Botany, production and uses. © CAB International, Wallingford, UK, pp: 193-220.

Scorza, R. and W.B. Sherman, 1996. Peaches. In Fruiting breeding. Vol.1: tree and tropical fruits. Edited by J. Janick and J.N. Moore. John Wiley & Sons, Inc., N.Y. pp. 325-440.

Shaltout, A. D., 1987. Florda Prince, a promising peach cultivar recently introduced to Egypt. Bull. Fac. of Agric., Univ. of Cairo, Vol.38, No.2: 381-391.

Shaltout, A. D., 1995. Introduction and production of some low-medium chill peach and apple cultivars in the sub-tropical climate of Egypt. Assiut Journal of Agricultural Sciences, Vol.26, No.1:196-206.

Shaltout, A. D., 2003. The peach industry in Egypt: state of art, research and development. First Mediterranean Peach Symposium, 10th of September 2003, Agrigento, Italy. http://unipa.it/medpeach/proccedings/

Tubbs, F.R., 1974. Rootstock/scion relations in horticultural crop physiology. Scientia Horticulturae. 2(3): 221-230.

Westwood, M. N., 1988. Temperate zone pomology. Third Edition. Timber Press, Portland, Oregon state university.

Wongtanet, D. and U. Boonprakob, 2010. Effect of rootstocks on growth of peaches in the highland of northern Thailand. Acta Horticulturae. 872: 327-332