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Effect of tree age of 'Newhall" navel orange on physical and chemical fruit characters development

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ABSTRACT

This study was carried out during two successive seasons (2014 and 2015) on Newhall navel orange trees (*Citrus sinensis* L. osbeck) 5, 10 and15- years old, to study effect of tree age on physical and chemical fruit characters. The results indicated that fruit weight, fruit size, peel thickness were higher with young 5-years old trees when compared with 10 and 15-years old trees. While, rind smoothness , juice percentage , total soluble solids (TSS) and TSS\ acidity (Tss\A) ratio were highest for 15-years-old trees compared with 5 and 10-years old trees .Moreover, rind smoothness correlated positively with nitrogen (N),phosphorous(P)and Calcium (Ca) content and negatively with manganese (Mn) in 15-years-old trees . Ca content correlated negatively with rind thickness in 5-years-old trees. Generally, proportional improvement happens in some physical and chemical fruit characters of 10 and 15-years old trees, compared with 5-years old trees. It could be recommended that physical and chemical fruit characters of citrus are changeable with tree age development until reaching maximum production stage.

***Keywords*:** Navel orange, tree age, vegetative growth, flowering, fruit quality.

Introduction

Citrus fruits are known for their distinctly pleasant aroma, arising due to the essential oil terpenes present in the rind. Orange produce very palatable juice and hence main for nutritious and popular breakfast (Singh and Rajam, 2009). Navel oranges are considered as one of most popular fresh fruit due to its seedless, large size, attractive for flavor and aroma (Wardowski *et al*., 1985). Citrus fruit quality may be indicated by external features, such as rind colour, size, and rind texture, and physical and biochemical characters of its internal features, like seediness, juice and vitamin C contents, TSS, T.AC and TSS\T.AC ratio (Ahmed, 2005). Fruit quality is influenced by several factors including cultural practices, such as pruning, irrigation, fertilizer application and plant protection measures (Mahmood and sheikh, 2006). Tree age plays an important role in fruit quality, but studies to determine its effect are rare in fruit crops and especially in citrus. Tree age affected acidity and TSS content of Satsuma mandarin (Matsumato *et al*., 1972) and juice content, TSS\T.AC ratio and ripeness index of oranges (Frometa and Echazabal, 1988).

Many researchers have determined the nutrient acquisition in different parts of citrus (Raza *et al*., 1999; Mattos *et al*., 2003 and Xiao *et al*., 2007). Some reports are available on nutrient content in relation to tree age in Navel orange (Storey and Treeby, 2000 & 2002), avocado (Snijder *et al*., 2002) and guava (Asrey *et al*., 2007) and correlation matrixes were established between fruit nutrient contents and fruit quality in citrus (Morgan *et al*., 2005).

The main purpose of the work is to investigate the effect of tree age on physical and chemical fruit characters of Newhall navel orange.

Materials and Methods

This study was carried out during two successive seasons (2014 and 2015) on healthy and nearly uniform Newhall navel orange trees (*Citrus sinensis* L osbeck) 5,10 and 15-years-old, budded on Volkamere lemon rootstock , in a private farm located in El-Behera Governorate, Egypt. The texture of the soil is sandy soil, trees grown at 5x5 m, under drip irrigation system. Five uniform and healthy trees per each age group were tagged.

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Experimental parameters:

1-Vegetative growth parameters:

The following characters were recorded new developing twigs from bud during growth cycles (spring, summer and autumn cycle): Out growth were used to study shoot length, shoot diameter, number of leaves\shoot and average leaf area was estimated by
leaf area meter (model C L 203 area meter CID. Inc. USA).

2-Flowering aspects:

Four branches as uniform as possible were chosen and 2 tagged around the periphery of each tree at mid-February in both seasons.
Total number of flowers, leafy inflorescence, leafless inflorescence and percentage of setting fruits during flowering and setting stages (mid-March to mid-May) were calculated as formula:

$$\text{Leafy inflorescence \%} = \frac{\text{Number of leafy inflorescence}}{\text{Number of inflorescence}} \times 100$$

$$\text{Fruit set \%} = \frac{\text{Number of developed fruitlets}}{\text{Persistent number of flowers}} \times 100$$

Developing flowers and post petal fruit borne on leafy inflorescence were characterized by significantly higher polyamine concentrations, faster growth rates and a greater percent fruit set than those born on leafless inflorescence (Lovatt *et al*., 1992).

Yield and fruit quality:

At harvesting time (Mid December to 1st January) in both seasons, the number of fruits and yield per tree (kg) were recorded. Sample of 10 fruits per each replicate were selected in the1st week of January to determine the fruit quality as follows : Fruit weight, fruit size, fruit shape index, rind smooth, peel thickness, juice percentage, total soluble solids (T.S.S), total acidity(T.AC), T.S.S\T.AC ratio and vitamin C content, according to A.O.A.C.,(1990) .

Different rating categories were used for the estimation of rind smoothness (1= very rough 2= rough 3= slightly smooth 4= smooth and 5= very smooth) (Samina *et al.,* 2012).

Leaf minerals content:

Samples of leaves, were taken in September (spring cycle) from each individual replicate (ten mature leaves) in both seasons were dried and ground, 0.5 gram of dried samples was digested using the H_2SO_4 and H_2O_2 as described by Cottenie, (1980) .

The extracted samples were used to determine the following nutrients:
Nitrogen: Total nitrogen was determined in the digested solution by using the microkjeldahl method as described by Horneck and Miller, (1998).
Phosphorus: was determined by using spectrophotometer 882 Mu according to method as outlined by Murphy and Riely, (1962).
Potassium: was determined photometrically using the method recommended by Horneck and Hanson, (1998).
Calcium, Magnesium, Ferric, Zinc and Manganese: were determined Spectrophotometricaly by an atomic absorption spectrophotometer as described by Brand and Spiner, (1965).
Total protein: was calculated using formula:
Protein % = Nitrogen % X 6.25.

Total indoles and phenols: Extraction of indolic compounds was conducted according to the method described by Daniel and George (1972).

The experiment consisted of three treatments arranged in a randomized complete block design. Five replicates were chosen for each treatment with one tree in each replicate. Least significant differences (L.S.D) at 0.05 (Steel and Torrie, 1984) were used for comparison between experimental treatments.

Results and Discussion

1-Vegetative growth:

The data presented in Table (1) showed significant increases in shoot diameter and number of leaves\shoots in 15-years old trees and non significant increases in shoot length and leaves area for 10 and 15- years old trees when compared with 5-years old trees, for both seasons .

These results are in harmony with these mentioned by Moss, (1969) they reported that, summer and fall flushes are less intense and produce almost exclusively vegetative shoots. Moreover, citrus major bloom occurs during the spring flush along with the vegetative sprouting. Also, Randhawa and Sinha, (1963) found that, positive correlation was observed between leaf area, number and growth elongation and the number of flowering shoots.

Table 1: Effect of tree age on vegetative growth behavior of Newhall navel orange trees during two successive seasons 2014 and 2015.

Tree ages	Spring shoots				Summer shoots				Autumn shoots			
	Shoot length (cm)	Shoot diameter (mm)	Leaf number	Leaf area (cm^2)	Shoot length (cm)	Shoot diameter (mm)	Leaf number	Leaf area (cm^2)	Shoot length (cm)	Shoot diameter (mm)	Leaf number	Leaf area (cm^2)
1st season												
5-years	15.6	3.2	10.7	17.9	21.9	3.6	13.6	20.8	28.9	4.7	17.0	7.3
10- years	16.4	3.1	5.3	20.6	25.6	3.9	15.7	23.0	33.4	5.6	14.7	27.8
15-years	16.8	3.3	9.7	21.3	24.3	3.8	16.3	23.7	34.2	5.73	13.41	29.1
L.S.D 5 %	N.S	0.14	0.84	N.S	N.S	0.09	N.S	N.S	N.S	N.S	N.S	N.S
2nd season												
5-years	19.4	3.1	11.0	18.4	20.4	3.4	14.4	21.4	29.7	4.81	16.3	23.4
10-years	21.7	2.9	9.5	19.6	24.7	3.7	15.9	22.6	31.5	5.6	15.5	25.6
15-years	20.9	3.2	9.2	22.0	25.3	3.8	16.7	24.3	33.8	5.8	14.8	26.3
L.S.D 5%	N.S	0.09	0.69	N.S	N.S	0.30	1.86	N.S	3.81	0.85	N.S	N.S

N.S : Non-significant

2-Blooming and setting:

Data in Table (2) indicated that, non- significant increases in total number of flowers for 10 and 15-years old trees. The maximum flowers number were (107.8 and 104.0) at 15-years old trees, followed by (105.8 and 90.4) of 10-years old trees. While, the lowest number (101.9 and 87.8) of 5-years old trees for both seasons, respectively.

These results are in line with those obtained by Singh and Samadar (1965) who revealed that, the number of flowers was found to be positively correlated with the length and leaf area of the shoots. In addition, citrus species usually produce a large number of flowers over the year. The floral load depends on the cultivar, tree age and environmental conditions (Monselise, 1986). Concerning leafy inflorescence percentage (LY%), it is clear from (Table 2) that, LY % was highest (72.1 and 73.8) at 15-years old trees and (68.0 and 67.8) in 10-years old trees, while, the lowest (56.17 and 60.4) in 5-years old trees for both seasons, respectively .These results are in harmony with Jahn (1973) who demonstrated that, citrus fruit set is highly dependent upon the type of inflorescence. In general, leafless inflorescences emerge first and contain a bouquet of flower with low probability to set fruit. On the other hand, flowers in leafy inflorescence that can be terminal or distributed among leaves along the shoot are commonly associated with higher fruit set. Moreover, Zidan (1959) found that, leafy flowering shoots were more prolific than leafless ones in both orange and mandarin.

Table 2: Effect of tree age on flowering and fruit set of Newhall navel orange trees during two successive seasons (2014 and 2015).

Tree ages	Total number of flower		Leafy inflorescence (LY) %		Fruit set %	
	1st season	2nd season	1st season	2nd season	1ST season	2nd season
5 years	101.9	87.8	56.17	60.40	2.33	1.92
10 years	105.8	90.4	68.0	67.8	3.78	3.50
15 years	107.8	104.1	72.1	73.8	3.96	3.90
L.S.D 5 %	N.S	N.S	N.S	N.S	0.29	0.32

N.S : Non significant

3-Fruit set percentage:

The data presented in (Table 2) revealed that, in the two successive seasons, significant increases in fruit set % at 15-years old trees (3.96 and 3.90) and (3.78 and 3.50) in 10-years old trees when compared with 5-years old trees (2.33 and 1.92) respectively .

These results were confirmed by Zidan, (1959) who indicated that, the average percentage of flowers producing mature fruits was 1.01 in the mandarin and 3.50 in the orange trees. Moreover, in comparison between lemon, lime, orange, mandarin, tangelo and bummelo trees, Fouque (1980) found that, orange performed best, with 12 % of the flowers producing 6 fruits at harvest. Also, Lovatt *et al*., (1984) reported that, nutritional status may affect flower formation and development and therefore fruit set.

4- Yield:

Data in (Table 3) showed that, in the two successive seasons, significant increases in yield as a number of fruits per tree and kg per tree, had the highest values were (388.7 & 389,4) fruits per tree and (104.4 &101.3 kg) per tree with 15-years old trees, followed by (329.0 & 333.3) fruits per tree and (92.2 & 90.1 kg) per tree in 10-years old trees, while, the lowest values (270.0 & 278.0) fruits per tree and (80.6 & 82.9 kg) per tree, respectively .

These results are in line with Zaman *et al.,* (2006) who reported that, tree age and size and yield maps produced similar spatial patterns with the grove, as high yielding areas were associated with large tree canopies. Therefore, tree canopy size could be used to estimate fruit yield within the grove.

Table 3: Effect of tree age on yield of newhall navel orange trees during two successive seasons (2014 and 2015).

Tree ages	Fruit number \tree		Yield (kg) \ tree	
	1st season	2nd season	1st season	2nd season
5 years	270.0	278.0	80.6	82.9
10 years	329.0	333.3	92.2	90.1
15 Years	388.7	389.4	104.4	101.3
L.S.D 5 %	15.30	17.75	10.2	9.7

Fruit quality:

Physical fruit characters:

Rind smoothness:

The results in (Table 4) clear that, rind smoothness scores (3.5 & 3.6) were high in fruits harvested from15-years old trees, whereas the lowest rind smoothness scores (2.4 & 2.6) were recorded in fruit of 5-years old trees.

Fruit weight:

First and second seasons results as shown in (Table 4) indicated that, significantly increase in fruit weight (298.4 & 298.2) for 5-years old trees compared with (268.77& 260.2) for 15-year old trees, while gave the intermediate values for 10-years old trees .

Fruit size:

The data presented in (Table 4) revealed that, fruit size was decreased significantly with tree age in the first season when compared size of fruit from 15-years old trees with 5-years old trees, while the data of second season not significant .

Fruit shape index:

Data in (Table 4) indicated that, fruit shape was not affected by tree age for both seasons.

Peel thickness:

Data presented in (Table 4) showed, non-significant and significant Increases in peel thickness for fruits from 5-years old trees than those from 1o and 15-years old trees in two successive seasons, respectively.

Table 4: Effect of tree age on physical fruit properties of Newhall navel orange trees during two successive seasons (2014 and 2015) .

Tree ages	Fruit weight (g)		Fruit size (cm^3)		Fruit shape index		Peel thickness (mm)		Juice (%)		Rind Smoth	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
5 years	298.4	298.2	317	305	1.16	1.16	5.63	5.55	49.2	51.8	2.4	2.6
10 years	280.2	270.3	285	274	1.15	1.14	5.60	5.13	55.0	56.3	3.2	3.3
15 years	268.7	260.2	279	271	1.15	1.13	5.52	5.02	58.4	57.6	3.5	3.6
L.S.D 5 %	18.59	27.38	28	N.S	N.S	N.S	N.S	0.17	3.03	6.08	0.09	0.11

N.S = Non-significant.

Juice percentage:

In the two successive seasons, significant increases were observed in juice % at fruit harvested from 15-years old trees when compared with those fruit harvested from 5-years old trees, while fruit from 10-years old trees gave the intermediate values.

In this respect, Ozeker, (2000) reported that, 20-years old trees of "March" seedless grape fruit produced bigger fruit with thinner rinds compared with 34-years old trees . Moreover, Samina *et al.* (2012) mentioned that, rind smooth, and juice mass % were highest in fruit from 15-years old trees of "Kinnow" mandarin compared with 6-years old trees .

Chemical fruit characters:

Total soluble solids (T.S.S):

Data presented in (Table 5) indicated that, total soluble solids significantly increased in fruits harvested from 15-years old trees when compared with those fruits of 5-years old trees, for both seasons.

Total acidity (T.AC) : The results showed that, total acidity % of fruits had decreased values (0.65 & 0.66) for fruits from 15-years old trees, followed by (0.66 & 0.68) in fruits from 10- years old trees, while the highest values (0.72 & 0.71) were belonged to fruits from 5-years old trees, in the two successive seasons .

T.S.S \ T.AC ratio:

Data in (Table 5) showed that, in the two successive seasons non-significant and significant increases at T.S.S\T.AC ratio in fruits harvested from 15-years old trees, compared with fruits from 5-years old trees, while fruits from 10-years old trees gave the intermediate values.

Vitamin C content:

The results in (Table 5) showed that, V.C content was not affected by tree age for both seasons. These results are in agreement with Matsumato *et al*., (1972) who found that, tree age affected acidity and TSS content of "Satsuma" mandarin and TSS\acid ratio of oranges (Frometa and Echazabal, 1988).

Table 5: Effect of tree age on chemical fruit properties of Newhall navel orange trees during two successive seasons (2014 and 2015).

Tree ages	T.S.S %		Acidity %		T.S.S\acid ratio		V.C content mg\100 g	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
5 years	9.9	10.2	0.66	0.68	14.93	15.0	33.3	33.4
10 years	11.3	11.5	0.72	0.71	15.73	16.27	35.5	32.7
15 years	11.7	11.6	0.65	0.66	18.20	17.70	34.0	33.9
L.S.D 5 %	1.22	0.21	N.S	N.S	N.S	2.7	N.S	N.S

N.S = Non significant

Macronutrient contents:

The results in (Table 6) clear that, N, P, Ca and Mg were higher in 15-years old trees, K was higher in10-years old trees when compared with 5-years old trees for both seasons. In 15-years old trees, N, K, and p content correlated positively with rind smoothness and negatively with Mn. Whereas, rind thickness correlated negatively with Ca, compared with 5-years old trees in the two seasons.

Table 6: Effect of tree age on macro nutrient content of Newhall navel orange trees during two successive seasons (2014 and 2015).

Tree ages	N		P		K		Ca		Mg	
	(%)									
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
5 years	1.80	1.92	0.12	0.11	1.80	1.77	1.75	1.80	0.65	0.63
10 years	2.10	1.95	0.13	0.13	2.20	1.98	1.89	1.93	0.73	0.76
15 years.	2.30	2.20	0.15	0.14	1.90	1.92	2.03	2.04	0.75	0.81
L.S.D 5 %	0.30	N.S	N.S	N.S	0.35	0.04	0.015	0.02	0.02	0.03

N.S = non-significant

Micro nutrient content:

Results as shown in (Table 7) indicated that, in the two successive seasons significant and non-significant increases were noticed in Fe, Zn, and Mn contents of 5- years old trees when compared with 10 and 15-years old trees. In this respect, Smith,(2003) and Tahir *et al*., (2007) reported that, for apple trees rind calcium (Ca) content correlated negatively with rind thickness which is consistent with the findings of Ali *et al* ., (2000) in the case of navel orange, macronutrient (Ca) was lower in younger than in older trees . Moreover, Storey and Treeby, (2002) indicated that, the leaves nutrient profile of young trees showed higher micronutrients (Zn, Mn and Fe) contents and lower macronutrients (N,P,K and Ca) . This might be due to the difference in mobility of these nutrients as N, P and K are phloem mobile, whereas Ca, Zn, Mn and Fe are xylem mobile nutrients. Also, Hubbard *et al*., (1999) found that, young citrus plants may have better mobility of xylem mobile nutrients, since it has been reported that xylem conductivity decreases with increasing tree age.

Table 7: Effect of tree age on micro nutrient and protein content of Newhall navel orange trees during two successive seasons (2014 and 2015).

Tree ages	Fe (ppm)		Zn (ppm)		Mn (ppm)		Protein content (%)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
5 years	0.87	0.82	77	82	49	52	11.25	12.00
10 years	0.82	0.87	75	85	46	51	13.13	12.19
15 years	0.75	0.81	74	81	48	55	14.38	13.75
L.S.D 5 %	0.03	0.02	N.S	N.S	N.S	N.S	N.S	N.S

N.S = Non-significant

Total protein content:

Data in (Table 7) revealed that, non-significant increases in protein content at 15-years old trees compared with 5 and 10-years old trees for both seasons. These results are in line with these mentioned by Margna, (1994) who reported that, protein degradation can be regarded as an alternative source for phenylalanine.

Indoles and phenols content:

a) Total indoles content:

The results in (Table 8) clear that, indoles content were significantly higher in 15-years old trees when compared with 5 and 10-years old trees especially during March and April for both seasons.

Table 8: Effect of tree age on total indols content of Newhall navel orange trees during the two successive seasons (2014 and 2015) .

Tree ages	Total indols content (mg\100 gm)							
	March		April		May		June	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
5 years	1.01	0.96	0.50	0.66	0.31	0.42	0.37	0.43
10 years	1.11	0.98	0.91	0.83	0.31	0.57	0.38	0.47
15 years	1.13	1.04	0.98	0.95	0.43	0.61	0.41	0.53
L.S.D 5 %	0.011	0.008	0.01	N.S	N.S	0.01	N.S	N.S

N.S = Non-significant

b) Total phenols content:

Data presented in (Table 9) reported that, non-significantly increases in phenols content at 5-years old trees compared with 10 and 15-years old trees especially during March and April in the two successive seasons.

Table 9: Effect of tree age on total phenols content of Newhall navel orange trees during two successive seasons (2014 and 2015).

Tree ages	Total phenols content %							
	March		April		May		June	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
5 years	0.17	0.15	0.16	0.17	0.14	0.13	0.12	0.13
10 years	0.14	0.13	0.15	0.14	0.13	0.12	0.12	0.12
15 years.	0.13	0.12	0.15	0.15	0.12	0.12	0.11	0.12
L.S.D 5 %	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

N.S = Non-significant

These results are in harmony with Treutter, (2005) he found that, phenolic compounds contribute significantly to plant resistance against the pests and environmental stress. Also, Norbak, (2003) reported that, the accumulation of phenolic compounds in barley tissues often negatively affected by high N-nutrition. The same results were obtained by Jaakola *et al*., (2002). They revealed that, at the early stages of bilberry fruit development, phenolick was major, but the levels decreased dramatically during ripening.

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