Journal of Horticultural Science & Ornamental Plants 11 (2): 134-143, 2019
ISSN 2079-2158

DOI: 10.5829/idosi.jhsop.2019.134.143

Effectiveness of Different NPK Fertilization Sources on Growth, Nutritional Status, Productivity and Fruit Quality of Washington Navel Orange Trees

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Abstract: This study was conducted during 2016 & 2017 seasons on 13-year-old Washington navel orange trees budded on Sour orange rootstock planted at 5 x 5 meters apart under surface irrigation in a private orchard at Manzala village, Toukh region, Qalubia Governorate, Egypt. The main goal of this investigation was directed towards increasing Washington navel orange trees growth, nutritional status, productivity and fruit quality associated with lowering its production cost through minimizing of chemical NPK fertilizers by granulated organic NPK, natural raw rocky materials and biofertilizers. The experiment included seven treatments; T_1-100% of chemical NPK, T_2- 100% of natural alternative NPK fertilizations mixture, T_3- 100% of NPK bio-fertilizations mixture, T_4– 50% of NPK bio-fertilizations mixture + 50% of natural alternative NPK fertilizations mixture., T_5- 50% of chemical NPK + 50% of natural alternative NPK fertilizations mixture, T_6- 50% of chemical NPK + 50% of NPK bio-fertilizations mixture and T_7- 33.3% of chemical NPK + 33.3% of NPK bio-fertilizations mixture + 33.3% of natural alternative NPK fertilizations mixture. Obtained results revealed that all investigated treatments increased growth parameters (number, length, thickness of developed shoots, number of leaves/each and leaf area), as well as total leaf chlorophyll and nutritional status (leaf N, P, K, Ca, Mg, Fe, Mn and Zn) and positively responded fruit (set% and retention%), yield/tree and fruit quality were also improved. However, T_1-100% of chemical NPK and T_7- 33.3% of chemical NPK + 33.3% of NPK bio-fertilizations mixture + 33.3% of natural alternative NPK fertilizations mixture were statistically the superior. Moreover, T_6 - 50% of chemical NPK + 50% of NPK bio-fertilizations mixture ranked statistically second in this concern.

Key words: Washington Navel Orange・Bio- NPK・Organic N・PK raw mineral・Productivity・Fruit Quality

INTRODUCTION

Washington navel orange (*Citrus sinensis* L. Osbeck) is one of the most important species in the genus Citrus in Egypt and ranked first among the species of citrus. It occupies about 35 % of the total cultivated area of citrus since its acreage reached about (181091) feddans with a total production of (1663284) tons per year [1].

Washington Navel orange is the most favorite cultivar in Egypt and it is considered popular fresh fruits due to seedless, large size, nutritive value, flavor and aroma characteristic. It is also a valuable source of early season income for citrus growers at some commercial citrus areas of the world. The total Value of mineral fertilizers has been significantly going up. As a result, it has become needful to seek alternatives that would supply the poor soil with more economical sources of fertilizers [2].

Adequate supplies of nitrogen (N), phosphorus (P) and potassium (k) are essential for citrus tree growth [3]. Nitrogen is the critical component in mineral fertilizers applied to citrus groves; it has more influence on tree growth, appearance and fruit quality than any other element [4]. Excess mineral nitrogen fertilization application enhances vegetative tree growth and may cause groundwater contamination if leached with excess irrigation [5]. Potassium is necessary for essential physiological functions such as the formation of sugars

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and starch, synthesis of proteins and growth [6, 7]. It is crucial in fruit formation and enhances fruit size, flavor and color. Phosphorus is prerequisite for many processes such as photosynthesis, synthesis and breakdown of carbohydrates and the transfer of energy within the plant [4].

Bio-fertilizers have mainly consisted of beneficial microorganisms that can release nutrients from rock and plant residues in the soil and make them available for economic crops. They are of the most important for plant production and soil fertility as they improve all properties of the soil. Moreover, biological fertilization plays a vital role in increasing the yield and fruit quality of citrus [8, 9].

Natural elements compound as feldspar, Sulphur and magnetite are used as a source of some nutrient minerals. Their use in nutrients management is considered clean and according to organic agriculture since these compounds improves soil aggregation, structure, permeability, infiltration, electrical conductivity (EC) and may overcome the harmful effect of saline water application. Moreover, Egyptian soils having alkaline pH are low in their available nutrients. Sulphur is frequently considered the essential amendment for soil reclamation and improvement through, reducing soil pH, improving water relations and the increasing availability of some nutrient elements needed for growth and yield [10, 11]. To decrease the dependence on imported potash, feldspar a potash mineral, containing 11.25% K_2O could be a potential K- source for crop production [12]. The utilization of potassium feldspar or crushed granite gave a yield response, although no higher than the usage of conventional fertilizers [13].

Thus, the essential objective of this investigation was directed towards increasing Washington navel orange trees growth, Nutritional Status, productivity and fruit Quality associated with lower its production cost through investigating the possibility of minimizing chemical NPK fertilizers and alternatively utilizing granulated organic N, PK natural raw rocky materials and/or biofertilizers.

MATERIALS AND METHODS

This study was executed during 2016 & 2017 seasons on 13-year-old Washington navel orange trees budded on Sour orange rootstock planted at 5 x 5 meters apart (168 trees/fed.) under surface irrigation in a private orchard at Manzala village, Toukh region, Qalubia Governorate, Egypt. All trees were undergone to the same horticultural practices adopted in the area according to

Table A: Some physical and chemical properties of the soil at start of the experiment

Soil physical properties	
Particle size distribution (%)	
C. Sand	11.2
F. Sand	18.2
Silt	18.2
Clay	51.4
Soil texture	Clay loam
Soil chemical properties	
OM (%)	3.40
pH	7.20
EC (dS m^{-1})	1.60
Soluble cations (meq l^{-1})	
Ca^{++}	8.80
Mg^{++}	3.25
Na^{+}	4.30
K^{+}	1.08
Soluble anions (meq l^{-1})	
CO_3^-	-
HCO_3^-	4.50
Cl^-	6.45
SO_4^{--}	8.00
Available NPK (mg/kg)	
N	24.50
P	11.40
K	170.5

the recommendations of the Ministry of Agriculture. It was devoted to investigate the effect of different NPK fertilization sources on growth, nutritional status, productivity and fruit quality of Washington navel orange trees. Before starting 1st season (2016) physical and chemical analysis of orchard soil surface (0- 40 cm depth) were determined according to Black *et al.* [14], as shown in Table (A).

The main goal was directed towards increasing Washington navel orange trees' growth, nutritional status, productivity and fruit quality associated with lower its production cost and consequently net growers income of such favorable cultivar through investigating the effectiveness of different NPK fertilization sources (the primary three expensive mineral concentrated NPK fertilizers with other cheaper and environment friendly natural alternative of NPK fertilizers and/or NPK bio-fertilizations mixture.

The common mineral NPK fertilization program adopted in the region in the form of ammonium sulphate, superphosphate and potassium sulphate yearly added at the rate of 5, 3 and 1 Kg per tree, respectively were also included as a control (100% chemical NPK) in this experiment. However, other investigated alternate NPK fertilizers sources were: 1- granulated organic N fertilizer of 18-20% actual N*., 2- two natural raw rocky materials, 1st as P fertilizer of 18-20 % actual P_2O_5 *, while 2 nd as K fertilizer of 10-12% actual K_2O* and 3- three biofertilizers **, i.e., a)- Nitrobein: - is a commercial nitrogenous bio-fertilizer contain specialized bacterial strains for free N fixation, b)- phosphorene: is a commercial phosphorus bio-fertilizer containing some active bacterial strains which facilitate P uptake through changing the insoluble tri-calcium phosphate (unavailable form) into available soluble one (mono- Calcium phosphate) and C) – Potassiem: is a commercial potassium bio-fertilizer that facilitates potassium releasing from clay complex components or between their mineral platelets layers. *Organic fertilizers were prepared, purified and salad by Alahram minning company. **Bio-fertilizers were prepared and marketing by Ministry of Agriculture.

Rate and Application Method of Different NPK Fertilization Sources: Three rates of chemical fertilizers NPK were employed in this study. The first rate was 100 % of chemical NPK (5, 3 and 1 kg per tree, respectively). The second rate was 50 % of chemical NPK (2.5, 1.5 and 0.50 kg per tree. The third rate was 33.3% of chemical NPK (1.66, 1 and 0.333 kg per tree, respectively); they applied at four equal batches in the first week of Feb. April, June and July. Besides, the three alternate NPK sources, i.e., granulated organic N fertilizer and granulated natural raw mineral rocky materials for either P or K fertilizers were mixed at three rates. The first rate was 100% of Natural alternative NPK fertilizations mixture (7.5, 5 and 4.5 kg per tree, respectively). The second rate was 50% of Natural alternative NPK fertilizations mixture (3.75, 2.5 and 2.25 kg per tree, respectively). The third rate was 33.3% of Natural alternative NPK fertilizations mixture (2.5, 1.67 and 1.50 kg per tree, respectively) they were added once at the first week of February. Moreover, three bio-fertilizers (Nitrobein, Phosphorene and Potassein) were also mixed at (1: 0.6: 0.4 by volume) for being soil drench applied at three rates. The first rate was 100% of NPK bio-fertilizations mixture (600 ml per tree). The second rate was 50% of NPK bio-fertilizations mixture (300 ml per tree). The third rate was 33.3% of NPK bio-fertilizations mixture (200 ml per tree) they were added once during the first week of February.

The Seven Treatments Involved in this Study Were Summarized as Follows:

T_1-100% of chemical NPK (the ordinary mineral NPK fertilization program adopted at 5, 3 and 1 kg/tree from $(NH_4)_2SO_4$, superphosphate and K_2SO_4, respectively) after the Ministry Of Agric. recommendation.

T_2 - 100% of Natural alternative NPK fertilizations mixture (organic N and PK raw mineral rocky materials).

T_3 - 100% of NPK bio-fertilizations mixture.

T_4 - 50% of NPK bio-fertilizations mixture + 50% of Natural alternative NPK fertilizations mixture.

T_5- 50% of chemical NPK + 50% of Natural alternative NPK fertilizations mixture.

T_6 - 50% of chemical NPK + 50% of NPK bio-fertilizations mixture.

T_7- 33.3% of chemical NPK + 33.3% of NPK bio-fertilizations mixture + 33.3% of Natural alternative NPK fertilizations mixture.

Experiment Layout: The complete randomized block design (with three replications was employed for arranging the seven investigated fertilization treatments, whereas a single tree represented each replicate. Consequently, 21 healthy fruitful Washington navel orange trees were carefully selected, as being healthy, disease-free and in the on-year state. Chosen trees were divided according to their growth vigor into three categories (blocks) each included seven similar trees for receiving the investigated seven fertilization treatments (a single tree was randomly subjected to one treatment).

Methodology, as has been reported in this study to evaluate the response to various investigated treatments, was carried out through determining changes in different measurements of the following examined characteristics:

On late March 2016 and early April 2017 four main branches (limbs/scaffolds) well distributed around each tree periphery were carefully selected and tagged during 1st and 2nd seasons, respectively. Moreover, 20 newly spring developed shoots were also labeled.

Vegetative growth measurements:

On mid-October 2016 and 2017 years, the following vegetative growth parameters were determined during 1st and 2nd experimental seasons, respectively.

In this regard, the average number of newly developed shoots per one meter of every tagged limb, average (length & thickness) and the number of leaves, per each labeled shoot were estimated. Besides, average leaf area (cm) on a weight basis was also determined. Hence, twenty mature leaves from the previously labeled shoots per each limb were randomly collected. Then 20 disks each of one cm. the area was taken and oven dried together with the rest leaves at 80°C till constant weight. Based on the known dry weight of a known surface area of leaves, i.e., 20 leaf discs from one hand and the total weight of 20 leaves from the other, then average leaf area in cm. was calculated. Moreover, assimilation area per one shoot according to the following equation: Assimilation area = leaf area x No. of leaves per one shoot.

Nutritional Status Measurements

Total Chlorophyll Content: Total chlorophyll content in fresh leaves was determined by using Minolta meter SPAD-502.

Leaf Mineral Composition: Representative samples of fourth and fifth leaves from the base of spring shoots were collected from each replicate in October during two experimental seasons. The samples were thoroughly washed with tap water, rinsed twice with distilled water and oven dried at 80°C till a constant weight and finely ground for determination of:

- Total Nitrogen: Total leaf (N) was determined by the modified micro Keldahl method mentioned by Pregl [15].
- Total phosphorus: Total leaf (P) was determined by wet digestion of plant materials after the methods described by using sulphuric and perchloric acid, which has been strongly recommended by Piper [16].
- Total potassium: Total leaf (K) was determined photometrically in the digested material according to the method described by Brown and Lilliand [17].
- Calcium and Mg percentage as well as Iron, Manganese and Zinc were determined using the Atomic absorption spectrophotometer "Perkin Elmer -3300" after Chapman and Pratt [18].

Productivity Measurements

Fruit Set Percentage: At full bloom during each experimental season, the number of perfect flowers per each tagged limb was counted. After 75% of petal fall fruit set as a percentage of perfect flowers were estimated according to the following equation:

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

Fruits Retention %: At a given date on December during each experimental season Percentage of retained fruits were estimated according to the following equations:

$$\text{Fruits retention \%} = \frac{\text{Number of presented (remained) fruits at a given date}}{\text{Number of set fruitlets}} \times 100$$

Yield: On mid-December 2016 and 2017, fruits of each tree were separately harvested, then counted and weighed. Tree productivity (yield) was estimated as either a number or weight (kg) of harvested fruits per each tree. Besides, yield per each tree.

Fruit Quality

Fruit Physical Properties: In this concern, average fruit weight (g.); dimensions (polar & equatorial diameters i.e., length & width in cm. & mm.); fruit shape index (length: width); juice volume and juice percentage and peel/rind thickness (mm) were the fruit physical properties investigated in this concern.

Fruit Chemical Properties: Fruit juice, total soluble solids percentage (TSS %) was determined using Carl Zeins hand refractometer. Total acidity as gms of unhydrous citric acid per 100ml fruit juice was determined after A.O.A.C. [19]. Total soluble solids/ acid ratio was also estimated. Ascorbic, acid/ Vitamin C content was determined using 2, six dichlorophenol indophenol indicator for titration after A.O.A.C. [19]. Moreover, total sugars% were determined after the method described by Smith *et al.* [20].

Statistical Analysis: All data obtained during both seasons for two experiments included in this investigation were subjected to analysis of variance according to Snedecor and Cochran [21]. Besides, significant differences among means were differentiated according to the Duncan, multiple test range [22] where capital letters were used for distinguishing means of different treatments for each investigated characteristic.

RESULTS AND DISCUSSION

Vegetative Growth Measurements: In this respect number of developed shoots per one meter of each tagged main branch (limb/scaffold), average shoot length & diameter, number of leaves per one shoot, average leaf area and total assimilation area shoot were the investigated growth parameters in response to the differential treatments. Data obtained during both 2016 and 2017 seasons are presented in Table (1).

Concerning the response of the number of abovementioned parameters to the different investigated nutrient treatments; Table (1) shows a considerable variation in this respect. Herein, the highest number of values were significantly coupled with the Washington navel orange trees subjected to T_1, T_7 showed significantly the same effectiveness in this concern. Moreover, the 6th treatment ranked statistically 2 ndon its efficiency. On the contrary, the least values of the abovementioned parameters were usually in concomitant to T_2 which ranked statistically last during both seasons of study.

Table 1: Effect of organic N, PK natural raw rocky materials and biofertilizers applications on some egetative growth parameters of Washington navel orange trees during 2016 and 2017 seasons

Treatments	No. of new shoots 2016	No. of new shoots 2017	Shoot length (cm) 2016	Shoot length (cm) 2017	Shoot thickness (mm) 2016	Shoot thickness (mm) 2017
T1- 100% chemical NPK	25.00 A	24.00A	35.00A	36.00B	3.20B	3.25B
T2- 100 % Natural alternative NPK	17.67F	15.67F	24.67F	25.93G	2.50G	2.54G
T3- 100 % bio- NPK	17.67E	17.00E	26.33E	27.33F	2.82F	2.85F
T4- 50 % bio- NPK + 50 % Natural alternative NPK	19.33D	19.33D	29.33D	30.00E	2.93E	2.97E
T5- 50 % chemical NPK + 50 % Natural alternative NPK	21.00C	20.33C	31.33C	32.67D	3.04D	3.07D
T6- 50 % chemical NPK + 50 % bio- NPK	23.67B	22.33B	32.67B	34.00C	3.14C	3.20C
T7- 33.3 % chemical NPK + 33.3 % Natural alternative NPK+ 33.3% bio- NPK	24.00AB	24.33A	35.67A	37.27A	3.26A	3.30A
	No. of leaves/shoot		Leaf area (cm^2)		Assimilation area (m^2/shoot)	
T1- 100% chemical NPK	35.00A	36.67B	17.66A	17.10A	6.18A	6.59B
T2- 100 % Natural alternative NPK	19.67F	22.33G	15.23F	15.66G	2.60F	3.50G
T3- 100 % bio- NPK	25.00E	27.67F	15.38F	15.85F	3.81E	4.38F
T4- 50 % bio- NPK + 50 % Natural alternative NPK	28.33D	29.67E	15.71E	16.00E	4.45D	4.76E
T5- 50 % chemical NPK + 50 % Natural alternative NPK	30.33C	32.67D	16.16D	16.36D	4.90C	5.34D
T6- 50 % chemical NPK + 50 % bio- NPK	33.33B	34.67C	16.76C	16.92C	5.58B	5.87C
T7- 33.3 % chemical NPK + 33.3 % Natural alternative NPK+ 33.3% bio- NPK	35.67A	38.00A	17.32B	17.99A	6.18A	6.77A

Means followed by the same letter/s within each column did not significantly differ at 5% level.

Besides, three other investigated nutritive compounds treatments, i.e., 3rd, 4th and 5th ones, were in between the previously mentioned two extremes. Such three intermediate nutritive compounds treatments didn't significantly different as compared to each other, regardless of the statistically varied as compared to those mentioned above superior and inferior treatments during two experimental seasons.

On the other hand, the noticeable positive effect of the investigated nutritive amendments may be attributed to the additional N source. Anyhow, the present results are generally in accordance with those previously found by Ebrahiem and Mohamed [23] on Balady mandarin, El-Sayed [24] on Washington navel orange Cv., Osman and Abd El-Rahman [25] on Fig trees, Darwesh [26] on costata persimmon trees, Zayan *et al*. [27] on Washington Navel Orange trees and EL-Gioushy *et al*. [28] on Fagri Kalan Mango trees.

Leaf Chemical Analysis

Leaf Total Chlorophyll: Data in Table (2) clearly indicate that T1and T7had a statistically superior effects and showed the highest total chlorophyll levels during 2016 & 2017 seasons, respectively. Other investigated fertilizers treatments could be descendingly arranged pertaining to their efficiency as follows: T6, T5 and T4. Taking into consideration that differences between and T3 in most cases didn't reach the level of significance during both seasons of study. Besides, the increase in leaf photosynthetic pigments content resulted by the investigated fertilizers treatments may be attributed to the paralleled increase in uptake of N which plays a vital role in the synthesis of such photosynthetic pigments as an essential constituent of the chlorophyll molecule.

Leaf Mineral Composition: In this regard leaf N, P, K, Ca, Mg, Fe, Mn and Zn contents of Washington navel orange trees as influenced by differential treatments were the concerned leaf mineral composition as an indicator for nutritional states of trees under study. Data obtained during both 2016 and 2017 experimental seasons are presented in Tables (2) and (3 revealed that all investigated treatments that included chemical fertilizers (100, 50 and 33.3%) resulted significantly in increasing Leaf mineral composition of Washington navel orange trees as compared to the other treatments. On the other side, Natural alternative NPK fertilizations mixture (organic N and PK raw mineral rocky materials) and NPK bio-fertilizations mixture (2nd & 3rd treatments) didn't significantly affect leaf mineral composition. Such a trend was true for both 2016 & 2017 experimental seasons.

However, T1 and T7 mixture had statistically the superior values whereas difference was so slight and could be safely neglected between the two treatments. Moreover, T6 ranked statistically 2nd, while came third. Such a trend was actual during both 2016 & 2017 experimental seasons.

Table 2: Effect of organic N, PK natural raw rocky materials and biofertilizers applications on total chlorophyll, N, P, K, Mg and Ca percentages of Washington navel orange trees during 2016 and 2017 seasons

Treatments	Total Chlorophyll		N%		P%		K%		Mg%		Ca%	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
T1- 100% chemical NPK	10.22A	10.36A	2.81A	2.84A	0.163B	0.163A	1.693A	1.707A	0.570A	0.616A	4.598A	4.619A
T2- 100 % Natural alternative NPK	8.81E	8.99F	2.28F	2.34F	0.129G	0.125F	1.357G	1.373F	0.393F	0.410F	4.224E	4.290D
T3- 100 % bio- NPK	8.63F	9.14E	2.41E	2.45E	0.138F	0.1333E	1.407F	1.440E	0.405E	0.458E	4.299D	4.371C
T4- 50 % bio- NPK + 50 % Natural alternative NPK	8.92D	9.38D	2.51D	2.61D	0.144E	0.141D	1.477E	1.503D	0.435D	0.473D	4.372C	4.448B
T5- 50 % chemical NPK + 50 % Natural alternative NPK	9.13C	9.63C	2.69C	2.68C	0.149D	0.148C	1.533D	1.553C	0.460C	0.487C	4.445B	4.464B
T6- 50 % chemical NPK + 50 % bio- NPK	9.81B	9.97B	2.77B	2.76B	0.157C	0.157B	1.610C	1.627B	0.515B	0.537B	4.487B	4.493B
T7- 33.3 % chemical NPK + 33.3 % Natural alternative NPK+ 33.3% bio- NPK	10.23A	10.29A	2.82A	2.85A	0.165A	0.164A	1.670A	1.707A	0.569A	0.612A	4.581A	4.605A

Means followed by the same letter/s within each column didn't significantly differ at 5% level.

Table 3: Effect of organic N, PK natural raw rocky materials and biofertilizers applications on Fe, Mn and Zn (ppm) contents of Washington navel orange trees during 2016 and 2017 seasons

Treatments	Fe (ppm)		Mn (ppm)		Zn (ppm)	
	2016	2017	2016	2017	2016	2017
T1- 100% chemical NPK	81.78A	82.90A	51.10A	49.63A	34.70A	34.70A
T2- 100 % Natural alternative NPK	66.97F	69.68F	33.95G	32.57F	22.74G	24.59G
T3- 100 % bio- NPK	70.13E	72.10E	35.62F	36.79E	25.72F	26.43F
T4- 50 % bio- NPK + 50 % Natural alternative NPK	73.30D	74.94D	37.57E	38.71D	28.58E	28.92E
T5- 50 % chemical NPK + 50 % Natural alternative NPK	76.77C	77.80C	40.31D	40.31C	30.62D	31.61D
T6- 50 % chemical NPK + 50 % bio-NPK	79.03B	80.63B	45.41C	45.91B	32.25C	32.47C
T7- 33.3 % chemical NPK + 33.3 % Natural alternative NPK+ 33.3% bio- NPK	81.57A	82.91A	49.69B	50.12A	33.95B	33.92B

Means followed by the same letter/s within each column didn't significantly differ at 5% level

An obtained result about the increase in Nutritional status measurements exhibited by investigated fertilizers treatments was in general agreement with the findings of Abdelaal *et al*. [29] on Washington Navel orange fruits, Sharaf *et al*. [30] on Washington Navel Orange trees, Baiea and EL-Gioushy [31] on banana cv. Grande Naine plants, EL-Gioushy [32] on young Manfalouty pomegranate trees and El-Badawy *et al*. [33] on Washington Navel Orange trees.

Fruit Measurements: In this regard percentage of both (fruits set & retention), tree productivity (yield) and fruits quality (physical & chemical properties) were the investigated fruiting parameters for Washington navel orange trees pertaining their response to the differential studied treatments.

Fruit Set and Retention %: Table (4) displays obviously that six investigated treatments increased the fruits set & retention % over T2 significantly. However, T1 and T7 was statistically the superior in this concern during both 2016 & 2017 experimental seasons. However, T6(ranked statistically second, descendingly followed by and T4 as both showed the same efficiency on fruit set & retention % during both seasons.

This result may be attributed to the relatively higher uptake of more accessible N form could be absorbed and/or translocated within tissues as a direct result of applying such N more productive compounds where an adequate and sufficient N level is needed at such critical stage of flower and fruit development.

The obtained result regarding the increment in fruit set & retention % exhibited by differential treatments goes in line with those found by Hegazi *et al*. [34] and Osman *et al*. [35] on some olive cultivars regarding the beneficial effect of bio and organic fertilizers on various flowering and fruiting characteristics gave support to the present result in this concern. Moreover, El-Mohamedy and Ahmed [36] on Balady mandarin, Vadak *et al.* [37] on sweet orange, Baiea and EL-Gioushy [38] on banana cv. Grande Naine plants, EL-Gioushy [32] on Young Manfalouty Pomegranate trees El-Badawy *et al*. [33] on Washington Navel Orange trees and Salama *et al.* [39] on Washington Navel Orange trees.

Tree Productivity (Yield): The yield of the Washington navel orange cv. expressed either as number or weight (kg) of harvested fruits per tree were the investigated two productivity parameters regarding the response to differential evaluated bio & organic compounds. Data obtained during both seasons are presented in Table (4). Herein, the cropping parameters of tree productivity followed the same trend, whereas T1 and T7 statistically surpassed all other treatments during both seasons of study. However, T6 ranked statistically second. On the contrary, T2 ranked statically last in this regard during

Table 4: Effect of organic N, PK natural raw rocky materials and biofertilizers applications on some fruiting aspects of Washington navel orange trees during 2016 and 2017 seasons

	Fruit set%		Fruit retention %		Average fruit weight (g)		No. of fruits /tree		Yield (kg) /tree	
Treatments	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
T1- 100% chemical NPK	21.96A	22.23A	15.70A	15.90A	290.07A	288.73A	168.00A	171.00A	48.74A	49.39A
T2- 100 % Natural alternative NPK	15.22G	15.93F	10.10E	10.55F	226.03F	229.73G	107.67E	115.00F	24.35F	26.44F
T3- 100 % bio- NPK	16.21F	16.69E	10.73D	11.10E	241.80E	245.63F	119.33D	123.67E	28.86E	30.39E
T4- 50 % bio- NPK + 50 % Natural alternative NPK	17.69E	17.94D	11.62C	12.55C	257.63D	261.07E	129.00C	129.33D	33.25D	33.78D
T5- 50 % chemical NPK + 50 % Natural alternative NPK	18.10D	18.31C	11.60C	11.95D	258.87D	264.67D	128.00C	129.33D	33.15D	34.24D
T6- 50 % chemical NPK + 50 % bio- NPK	19.41C	19.70B	13.69B	14.37B	271.27C	276.27C	150.33B	151.67C	40.80C	41.92C
T7- 33.3 % chemical NPK + 33.3 % Natural alternative NPK+ 33.3% bio- NPK	21.57B	22.18A	15.55A	16.04A	286.17B	285.60B	167.00A	168.33B	47.81B	48.10B

Means followed by the same letter/s within each column didn't significantly differ at 5% level.

both seasons of study. Such three effective treatments (T1, T7 and T6) were significantly different as compared to each other regarding their efficiency on increasing productivity.

Obtained results regarding the positive influence of differential investigated treatments on the increasing yield of Washington navel orange cultivars are in harmony with that reported by Mansour and Shaaban [40] on Washington Navel Orange trees, Khafagy *et al.* [41] on Nave orange trees, Baiea *et al*. [38] on Banana cv. Grande Naine, El-Badawy *et al*. [42] on Washington Navel Orange trees and EL-Gioushy *et al*. [28] on Fagri Kalan Mango trees.

Nevertheless, the rate of increase in most nutritional status measurements by the effective fertilization treatments was usually lower than the corresponding ones of the vegetative growth measurements. So, such a trend could be logically explained as an expected dilution effect resulted from the relative higher accumulation rate of assimilated dry matter corresponding to the lower rate of increase in most nutrient elements.

Fruit Quality

Fruit Physical Properties: In this regard, Peel thickness, fruit dimensions (equatorial & polar diameters), fruit shape index and juice weight and percentage were the evaluated fruit physical properties of Washington navel orange Cv. in response to the differential investigated fertilizers treatments. Data obtained during both 2016& 2017experimental seasons are presented in Table (5).

As shown from Table (5) that fruit physical properties of Washington navel orange Cv. were increased significantly by applying any of the investigated fertilizers treatments as compared to T_2 during both experimental seasons. However, the greatest increase was statistically detected by both T_1 and T_7, both effective treatments showed approximately the same values of different fruit physical properties. Moreover, T_6 ranked statistically second, descendingly followed by T_5. Such a trend was true during both seasons of study with limited exceptions, especially with fruit shape index. Concerning the fruit shape index (polar diameter: equatorial diameter) of Washington navel orange cv. in response to the different investigated treatments, Table (5) shows clearly that the variances were relatively too few to be taking into consideration from the statistical point of view. Variations in fruit shape indices due to the differential investigated fertilizers treatments could be logically explained on the unparalleled response of two fruit dimensions (polar & equatorial diameters) to a given treatment. In the most cases, the increase in fruit length (height or polar diameter) was relatively higher than those resulted in fruit width (equatorial diameter) as the response to each treatment was individually (separately) taking into consideration.

Moreover, obtained results regarding the positive effect of differential fertilizers application on some physical fruit characteristics generally goes in the line of several investigators findings, i.e., Abd El-Migeed *et al*. [43] on Washington navel orange trees, El-Mohamedy and Ahmed [36] on Balady mandarin, Sharaf *et al*. [[30] on Washington Navel orange trees, EL-Gioushy [44] on Washington Navel orange trees, Zayan *et al*. [27] on Washington Navel orange trees , Abd-El-Latif *et al*. [45] on "Le-Conte" pear trees and El-Badawy *et al*. [42] on Washington Navel Orange trees.

Fruit Chemical Properties: In this regard fruit juice total soluble solids (TSS) %, total acidity %, TSS / acid ratio, total sugars % and ascorbic acid (vitamin C) contents were the five investigated fruit juice chemical properties for Washington navel orange cv. regarding their response to the differential treatments. Data obtained during both 2016 & 2017 experimental seasons are presented in Table (6). Herein, it is quite clear that the response of fruit juice chemical properties for Washington navel orange cv. to the different investigated treatments followed to a great extent the same trend previously detected with fruit physical properties. However, the differences were relatively firmer with fruit physical properties.

Table 5: Effect of organic N, PK natural raw rocky materials and biofertilizers applications on some fruit physical properties of Washington navel orange trees during 2016 and 2017 seasons

Treatments	Peel thickness (mm)		Polar diameter (cm)		Equatorial diameter (cm)		Fruit shape index		Juice weight (g)		Juice %	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
T1- 100% chemical NPK	3.18A	3.23A	8.42A	8.39A	8.44A	8.41A	0.997A	0.998A	127.66A	126.13A	44.00AB	43.67A
T2- 100 % Natural alternative NPK	2.69G	2.71G	7.81F	7.85F	7.83E	7.87E	0.998A	0.997A	90.51E	92.05F	40.03F	40.06D
T3- 100 % bio- NPK	2.72F	2.76F	7.92E	7.96E	7.94D	7.99D	0.997A	0.997A	100.72D	103.14E	41.65E	41.99C
T4- 50 % bio- NPK + 50 % Natural alternative NPK	2.82E	2.86E	8.02D	8.07D	8.04C	8.10C	0.997A	0.997A	108.83C	111.13D	42.24DE	42.56BC
T5- 50 % chemical NPK + 50 % Natural alternative NPK	2.95D	3.01D	8.04D	8.07D	8.06C	8.10C	0.997A	0.997A	111.19C	114.40C	42.95CD	43.22AB
T6- 50 % chemical NPK + 50 % bio- NPK	3.03C	3.09C	8.18C	8.20C	8.21B	8.22B	0.997A	0.998A	117.73B	121.20B	43.40BC	43.87A
T7- 33.3 % chemical NPK + 33.3 % Natural alternative NPK+ 33.3% bio- NPK	3.16B	3.21B	8.37B	8.37B	8.39A	8.40A	0.998A	0.997A	127.12A	125.78A	44.41A	44.04A

Means followed by the same letter/s within each column did not significantly differ at 5% level.

Table 6: Effect of organic N, PK natural raw rocky materials and biofertilizers applications on some fruit chemical properties of Washington navel orange trees during 2016 and 2017 seasons

Treatments	T.S.S %		Total acidity %		TSS/Acid ratio		Total sugars %		V.C	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
T1- 100% chemical NPK	12.13A	12.13A	1.049A	1.488A	8.520A	8.527A	11.57A	8.55D	62.49A	62.91A
T2- 100 % Natural alternative NPK	9.89F	9.74F	1.007AB	1.016B	7.683G	7.627A	9.82C	9.59CD	51.92G	52.60G
T3- 100 % bio- NPK	10.24E	10.42E	0.961BC	0.899B	7.940F	7.950A	10.68B	11.58AB	53.36F	53.93F
T4- 50 % bio- NPK + 50 % Natural alternative NPK	10.81D	10.95D	0.924C	0.856B	8.037E	8.010A	11.72A	12.81A	55.02E	55.67E
T5- 50 % chemical NPK + 50 % Natural alternative NPK	11.06C	11.16D	1.041A	1.044B	8.207D	8.207A	10.62B	10.69BC	56.64D	57.16D
T6- 50 % chemical NPK + 50 % bio- NPK	11.66B	11.68B	0.975B	0.965B	8.320C	8.277A	11.95A	12.09AB	57.47C	58.10C
T7- 33.3 % chemical NPK + 33.3 % Natural alternative NPK+ 33.3% bio- NPK	12.07A	12.01A	1.006AB	1.002B	8.427B	7.107A	11.99A	11.98AB	60.67B	62.01B

Means followed by the same letter/s within each column did not significantly differ at 5% level.

Hence, T_1 and T_7, i.e., (100% chemical NPK) and (33.3 % chemical NPK + 33.3 % Natural alternative NPK+ 33.3% bio- NPK), respectively were statistically the most effective and showed significantly the same level fruit juice chemical properties for Washington navel orange cv. during both experimental seasons.

Moreover, T_6 ranked statistically second on influencing fruit juice chemical properties. The reverse was true with T_2 which significantly induced the poorest fruit juice chemical properties during both seasons. Besides, other investigated treatments were in between the abovementioned two extremes. Such a trend was real during both seasons of study with limited exceptions, especially with TSS / acid ratio, which was slightly influenced by the differential investigated treatments. Such trend of response (relative lower differences in fruit juice TSS/Acid ratio to various studied treatments) could be logically explained depending upon the paralleled rates of changes exhibited in both fruit juice TSS and total acidity parameters to a given investigated treatment with little exceptions in the first season.

The present result goes partially in line with that pointed out by several investigators regarding the beneficial effect of differential fertilizers on improving fruit juice chemical properties i.e., Gill *et al*. [46] on Kinnow mandarin, Mansour and Shaaban [40] on Washington Navel orange trees, Abdelaal *et al*.[29] on Washington Navel orange fruits. Sarrwy *et al*. [47] on "Balady" Mandarin trees, El-Gioushy and Baiea [48] on Canino Apricot, Abd-El-Latif *et al*. [45] on "Le-Conte" pear trees and Salama *et al.* [39] on Washington Navel Orange Trees.

CONCLUSION

Conclusively, from the obtained results, it can be concluded that using of 33.3% of chemical NPK + 33.3% of NPK bio-fertilizations mixture + 33.3% of Natural alternative NPK or 50% of chemical NPK + 50% of NPK bio-fertilizations mixture fertilizations could be safely recommended, as their beneficial effects on vegetative growth, nutritional status, productivity and fruit quality of Washington navel orange trees grown under similar environmental conditions and horticulture practices adopted in present experiment.

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