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Improving Yield and Fruit Chemical Properties in Washington Navel Orange by Bio-and Nitrogen Fertilizers

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Abstract

The field experiment was carried out during 2020/ 2021 and 2021/2022 seasons on Washington Navel orange and grown in a private citrus orchard located at Wady Al-Mollak, district Al-Ismailia Governorate, Egypt. Used complete block randomized design with three replicates. Thirteen treatments were applied as a combination between amount of bio fertilizer (3, 4, 5 L) and four levels of mineral nitrogen (100, 90, 80, 70 kgN/fed) as well as control (0 L. Bio 100 kgN/fed). The results showed that significant between treatments for all studies characters. The treatment 5 L. Bio. + 100 kgN/fed, given the highest values of number of flowers, fruit set%, tree yield/kg and fruit yield/fed (ton). Also, this treatment improved fruit chemical properties. It can be concluded that 5 L. Bio. + 100 kgN/fed enhancement total number of flowers, fruit set percentage, yield/tree and fed. as well as fruit chemical characters.

Keywords: Washington, orange, bio-fertilizers, fruit set, yield, fruit properties.

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1. Introduction

Citrus fruits are one of the major fruit crops with dietary significance, worldwide accessibility, and recognition [1,2,3]. More than 140 countries throughout the world cultivate citrus fruits; however, the majority of the crop is grown in tropical and subtropical climates, with most of the cultivation and production taking place in the Northern Hemisphere [4]. Citrus tree nutritional status is a major factor affects growth, development, yield, and fruit quality [5]. Applications of bio-fertilizers are now available commercially. Specific strains are used as biological fertilizers, for nitrogen, phosphorus and silicate dissolving such as N-fixing bacteria and yeasts. The use of these materials encourages growth and flowering as well as reflected positively on tree productivity. There are various benefits of bio-fertilizers as they increase supplement of various nutrients, eco-friendly, cost-effective, improve fruit quality, and help plant to tolerate stress conditions [6]. Using organic and bio fertilizers considered a key tool for sustainable horticulture crop production system, it offers improving soil health, increasing crops, and enhancing fruit quality, minimizing costs, and sustains natural resources [7]. Bio-fertilizers must be a part of the integrated fertilizing system with synthetic fertilizers to improve the soil characters and sustain horticultural crop productivity [8]. Furthermore, the combination of organic and bio-fertilizer, causes a slow release of nitrogen needed for nutrition during fruit growth period causing an increase in fruit size moreover higher uptake of water and nutrients as potassium due to the bio-fertilizer, lead to increase of water content in peel and pulp [9]. [10] found that the use of bio-fertilizers significantly improved yield and fruit quality of pomegranate in India. In addition, Bio-fertilization considered a positive alternative to chemical fertilization lost the enhancing enhance citrus yield and fruit quality, because it is safe for human, animal, and environment. Using bio-fertilizers in organic food production accompanied with the reduction of environmental pollution. Application of mineral fertilizers with organic or bio-fertilizers proved to be highly effective in improving nutritional status, fruiting and fruit quality of various fruit trees [11,12].

The N demand of citrus trees is reflected mainly by the N concentration and its partitioning in the leaves [13]. Although the leaves of citrus trees make up only 21% of their aboveground biomass, they contain ~31–41% of the aboveground nutrients [14]. Moreover, the yield of citrus is largely determined by the N concentration of the leaves [15].

Therefore, the present study aimed to investigation is application of some bio- and mineral nitrogen on flowering, yield and fruit chemical characters of fruitful Washington Navel orange trees.

2. Materials and Methods

The field experiment was carried out during 2020/ 2021and 2021/ 2022 seasons on Washington Navel orange trees and grown in a private citrus orchard located at Wady Al-Mollak, district Al-Ismailia Governorate, Egypt. Trees were planted at 5×5 m apart (168 trees/Faddan), the trees 10- years-old in sandy soil.

2.1. Experimental design and tested treatments

A- Nitrogen fertilizers: used four different treatments of nitrogen fertilizers were as follows:

1-100 units N/fed., as follows: During the first week of March (early spring) of both seasons, trees received 100 kg/feddan of calcium nitrate. Another 50 liter/feddan of nitric acid added set fertilization was repeated again in both seasons by adding 230 kg/feddan of ammonium nitrate, At a rate of 595 g N/tree.

2-90 units N/ fed., as follows: During the first week of March (early spring) of both seasons, trees received 100 kg/feddan of calcium nitrate. Another 50 liter/feddan of nitric acid added after fruit set fertilization was repeated again of both seasons by adding 200 kg/feddan of ammonium nitrate. At a rate of 535 g N./tree.

3- 80 units N/fed., as follows: During the first week of March (early spring) of both seasons, trees received 100 kg/feddan of calcium nitrate. Another 50 liter/feddan of nitric acid added after fruit set Fertilization was repeated again of both seasons by adding 170 kg/feddan of ammonium nitrate. At a rate of 476 g. N/tree.

4- 70 units N/fed., as follows: During the first week of March (early spring) of both seasons, trees received 100 kg/feddan calcium nitrate. Another 50 liter/feddan of nitric acid added after fruit set Fertilization was repeated again of both seasons by adding 140 kg/feddan ammonium nitrate. At a rate of 416 g N/tree.

The treatments were carried out with nitrogen fertilizers in three doses as follows: During the first week of March (early spring) of both seasons, trees calcium nitrate. Another of nitric acid added in May after fruit set Fertilization was repeated again in July of both seasons by adding ammonium nitrate.

B- Bio-fertilizers: used four treatments of mega plus as follows: -

1- Control at zero/tree.

2- At 93 cm^3/tree.

3- At 125 cm^3/tree.

4- At 156 cm^3/tree.

The field experimental was complete block randomized design the treatments were ((Cont. 0 Bio. +100 kg N/fed), (3 L. Bio. + 100 kg N/fed), (3 L. Bio. + 90 kg N/fed), (3 L. Bio. + 80 kg N/fed), (3 L. Bio. + 70 kg N/fed), (4 L. Bio. + 100 kg N/fed), (4 L. Bio. + 90 kg N/fed), (4 L. Bio. + 80 fed.), (4 L. Bio. + 70 kg N/fed), (5 L. Bio. + 100 kg N/fed), (5 L. Bio. + 90 kg N/fed), (5 L. Bio. + 80 kg N/fed), (5 L. Bio. + 70 kg N/fed)). With three replicates was used to implement the field experiment, whereas each replicate was represented by a single tree. Consequently, thirty-nine healthy fruitful Washington Navel orange trees were carefully selected, disease free and in the on-year state, the trees 10-years-old in a sandy soil. Physical and chemical characteristics of the soil at the experimental site.

Table 1: Physical and chemical properties of the soil at the experimental site

Constituents	Values	Constituents	Values
Particles size distributions (%)		Soluble anions (mmolc L^{-1})	
Sand	94.2	Co	-
Silt	2.4	HCo_3	0.075
Clay	3.4	CI	0.43
Texture grade	Sandy soil	So_4	7.065
Chemical properties		Extractable macronutrients (ppm)	
Ph	8.38	N	60
E.C (dS m^{-1})	0.757	P	2.5
$CaCo_3$(%)	1.69	K	10.3
Soluble cations (mmolc L^{-1})		DTBA extractable micronutrients (ppm)	
Ca	0.14	Fe	0.22
Mg	0.11	Mn	0.24
Na	7.11	Zn	0.2
K	0.21	Cu	0.22

2.2. Data recorded as follows

A. Yield and its components

1- Number of flowers (leaf/wood): It was calculated used total flowers per shoots during full bloom.

2- Percentages of fruit set (leaf/wood): Fruit set was calculated two weeks after full bloom in April during both seasons using the following equation:

$$\text{Fruit set (\%)} = \frac{\text{Total fruit number x 100}}{\text{Total flowers number}}$$

3- The percentage of remaining fruit: was calculated again after June drop using the following equation:

$$\text{Final fruit set (\%)} = \frac{\text{Number of remaining fruit after June drop x 100}}{\text{Total flowers number}}$$

4- Tree yield (kg): average fruit weight (g) * fruit number per tree/1000 was calculated at harvest time.

5- Total yield (ton/fed): average tree yield (kg) * 168/1000 was calculated at harvest time.

B. Chemical fruit characters

Sample of fruits juice filtered through muslin cloth to determine the following chemical characteristics:

1- Total soluble solids (TSS): It was measured using a refractometer, according to [16].

2- Total acidity: Juice samples was filtered and used to determine total acidity using the titration method against NaOH (0.1 N) in the presence of phenol phethalein, as an indicator, according to [17] to calculate citric acid (mg) per100 ml juice.

3- TSS/TA ratio: it was computed by using the TSS on TA.

4- Ascorbic acid (Vitamin C) content: This was determined in filtered juice samples and expressed as mg/100 ml juice, as described by [16] using 5ml juice sample and 5ml of oxalic acid solution (2%), and then titrated against 2,6-dichlorophenolendophenol indicator dye to the end point (the appearance of pink color) to calculate vitamin C.

5- Total phenols: Total phenolic were determined by Folin-Ciocalteu method of [18].

6- Total, reducing and non-reducing sugars: Total sugars% was determined after the method described by [19]. The reducing sugars were determined by the Nelson arsenate-molybdate colorimetric method [20]**.** The non-reducing sugars were calculated by the difference between total sugars and reducing sugars.

2.3. Statistical analysis

According to statistical analysis method stated by [21], the data were subjected to calculate the analysis of variance. Means were compared using least significance difference (LSD) at P≤0.05 according to [22]. Statistix 8.1 was used to conduct all statistical analyses (Analytical Software, 2005).

3. Results and Discussion

3.1. Yield and its components

3.1.1. Flowering

The present data in Table (2) showed that the significant deference between levels of bio- and nitrogen fertilization for No. of flowers leaf/shoot, No. of flowers wood/shoot, number of total flowers/shoot, percentage of flowers leaf /shoot%, and percentage of flowers wood/shoot % in both seasons. The highest values of No. of flowers leaf/shoot in first season were recorded by 5 L. Bio. + 100 kg N/fed and 5 L. Bio. + 90 kg N/fed, meanwhile in second season was obtained by 5 L. Bio. + 100 kg N/fed. The highest values of No. of flowers wood/shoot was recorded by 5 L. Bio. + 100 kg N/fed in both seasons. The highest values of number of total flowers/shoot in both seasons by addition 5 L. Bio. + 100 kg N/fed in first and second seasons. Also, the highest values of percentage of flowers leaf or wood /shoot were obtained by 5 L. Bio. + 100 kg N/fed. Our results agreed with those obtained by [23] on lemon, [24] reported organic, bio-fertilizers and NPK alone or combined together significantly decreased the percentages of June drop and preharvest drop in Navel orange. [25] indicated a positive effect of fertilization regimes, which include organic and bio- fertilizers, on fruit set percentage of orange tree. [26] on Valencia orange tree.

3.1.2. Fruit set %

The results in Table (3) showed that the significant deference between fertilizers treatments for fruit set leaf flowers %, fruit set wood flowers % and percentage for no. of fruit/ total flowers after June %/shoot. Fruit set (%) take the same trend of number of flowers and their percentages. Application 5 L. Bio. + 100 kg N/fed gave the highest values of fruit set leaf flowers % (14.77 and 11.45%), fruit set wood flowers % (1.61 and 1.51%) and no. of fruit/ total flowers after June %/shoot (3.27 and 2.85%), respectively in both seasons. The other tested treatments came in between in both lasted seasons. Our results agreed with those obtained by our results agreed with those obtained by [23] on lemon, [24] reported organic, bio-fertilizers and NPK alone or combined together significantly decreased the percentages of June drop and preharvest drop in Navel orange. [28] indicated that initial fruit setting of Navel orange trees increased positively with increasing nitrogen levels from 100 to 140 kg N / feddan either used ammonium nitrate (33.5%) or ammonium sulfate (20.6%) as a source of nitrogen. The best results were obtained by using 120 kg N/feddan/year. [25] indicated a positive effect of fertilization regimes, which include organic and bio-fertilizers, on fruit set percentage of orange tree. [26] on Valencia orange trees.

Table 2: Flower characters as affected by bio-fertilizer and nitrogen rates on Washington Navel orange during two seasons

Characters	No. of flowers leaf/shoot		No. of flowers wood/shoot		Number of Total flowers/shoot		Percentage of flowers leaf /shoot%		Percentage of Flowers wood/shoot %	
Seasons Treatments	2021/22	2022/23	2021/22	2022/23	2021/22	2022/23	2021/22	2022/23	2021/22	2022/23
Cont. 0 Bio.+100 kg N/fed.	84 fg	84h	153f	177e	236e	261f	35.33cd	32.30g	64.67de	67.70b
3 L. Bio. + 100 kg N/fed	121 c	116c	233 b	226a	350ab	320a-e	34.10 def	33.93ef	65.90bcd	66.06cd
3 L. Bio. + 90 kg N/ fed.	122bc	115c	173e	194d	296cd	309cde	37.97b	37.33b	58.57g	62.66g
3 L. Bio. + 80 kg N/ fed.	92 ef	99f	166e	196d	258de	294e	35.53cd	33.43f	64.47de	66.56c
3 L. Bio. + 70 kg N/ fed.	77 g	94g	211c	208bc	291cd	302de	26.73g	31.26h	62.03f	61.70h
4 L. Bio. + 100 kg N/ fed.	130 ab	120b	217c	224a	377a	344a	34.47de	34.96cd	65.53cd	65.03ef
4 L. Bio. + 90 kg N/ fed.	122 bc	119b	206cd	209bc	328bc	333abc	37.20 bc	35.80c	62.80ef	64.20f
4 L. Bio. + 80 kg N/ fed	95 e	107e	197d	205c	292cd	319a-e	32.40f	33.96ef	67.60b	66.03cd
4 L. Bio. + 70 kg N/ fed.	105 d	107e	210c	197d	315bc	312b-e	33.30ef	34.26def	66.70bc	65.73cde
5 L. Bio. + 100 kg N/ fed.	133 a	122a	247a	229a	351ab	346a	41.43a	38.30a	73.27a	68.73a
5 L. Bio. + 90 kg N/ fed.	133a	110d	217c	210bc	350ab	320a-e	38.10b	34.43de	61.90f	65.56de
5 L. Bio. + 80 kg N/ fed.	106 d	115c	207cd	210bc	313bc	341 ab	33.97def	33.43f	66.03bcd	66.56c
5 L. Bio. + 70 kg N/ fed.	111 d	112d	213c	215b	324bc	326a-d	34.27def	34.26def	65.73bcd	65.73cde
LSD at 5%	8	2	12	7	48	29	1.97	0.90	1.97	0.90

Similar letter(s) in the same column are non-significant statistically at 0.05 level of probability

Table 3: Fruit set percentages as affected by bio-fertilizer and nitrogen rates on Washington Navel orange during two seasons

Characters	Fruit set flowers leaf %		Fruit set flowers wood %		Percentage for no. of fruit/ total flowers after June %/shoot	
Seasons Treatments	2021/22	2022/23	2021/22	2021/22	2021/22	2022/23
Cont. 0 Bio.+100 kg N/ fed.	7.97def	10.34b	1.47ab	1.27bc	1.38e	2.52ab
3 L. Bio. + 100 kg N/ fed.	8.30c-f	8.53d	0.93cd	0.96e	1.49de	1.66ab
3 L. Bio. + 90 kg N/ fed.	9.93b-e	10.55ab	1.11bcd	1.37b	2.49abc	2.30ab
3 L. Bio. + 80 kg N/ fed.	10.03bc	9.22cd	1.04cd	1.02e	2.39bc	1.49b
3 L. Bio. + 70 kg N/ fed.	13.10a	7.41e	1.07bcd	0.723f	2.43abc	1.42b
4 L. Bio. + 100 kg N/ fed.	12.97a	10.75ab	0.94cd	1.23cd	2.66ab	2.91a
4 L. Bio. + 90 kg N/ fed.	9.87b-e	7.62e	0.83d	0.94e	2.10bcde	1.75ab
4 L. Bio. + 80 kg N/ fed.	9.13b-f	10.87ab	1.32abc	1.24cd	1.73cde	1.77ab
4 L. Bio. + 70 kg N/ fed.	7.93ef	10.51b	0.79d	1.38b	2.29bcd	2.10ab
5 L. Bio. + 100 kg N/fed.	14.77a	11.45a	1.61a	1.51a	3.27a	2.85a
5 L. Bio. + 90 kg N/ fed.	7.73f	10.03bc	1.03cd	1.15d	2.20b-e	2.42ab
5 L. Bio. + 80 kg N/ fed.	10.37b	10.37b	1.09bcd	0.94e	2.52abc	2.06ab
5 L. Bio. + 70 kg N/ fed.	10.00bcd	9.03d	1.18bcd	0.97e	2.20b-e	2.19ab
LSD at 0.05%	2.04	0.91	0.43	0.13	0.86	1.33

Similar letter(s) in the same column are non-significant statistically at 0.05 level of probability

3.1.3. Fruit yield

Data in Table (4) showed that the significant deference between fertilizers treatments for tree yield (kg) and fruit yield/ fed. (ton). The highest values of tree yield obtained by 5 L. Bio. + 100 kg N/ fed. (136.0 and 119.0 kg), in first and second seasons, respectively. Also, the highest value of fruit yield/fed (ton) was recorded by the previous treatment (22.8 and 20.0 ton/fed.) in first and second seasons was recorded, respectively. Bio-fertilizers must be a part of the integrated fertilizing system with synthetic fertilizers to improve the soil characters and sustain horticultural crop productivity [8]. Our results agreed with those obtained by [27,25,26] on Valencia orange, [10] on pomegranate, [29] on lemon. [30] reported that, number of fruits per tree and average weight of fruits significantly increased with organic, inorganic fertilizers and inoculation by Azospirillum and phosphate solublizing bacteria (*Bacillus megatherium*) on sweet orange, [31] on acid lime tree and [32] on Nagpur mandarin tree.

Table 4: Fruit yield as affected by bio-fertilizer and nitrogen rates on Washington Navel orange during two seasons.

Characters	Tree yield/kg		Fruit yield/fed. (ton)	
Seasons / Treatments	2021/22	2022/23	2021/22	2022/23
Cont. 0 Bio.+100 kg N/ fed.	97.7cde	90.7f	16.4bc	15.2abc
3 L. Bio. + 100 kg N/ fed.	107.7cd	102.0d	18.1abc	18.1abc
3 L. Bio. + 90 kg N/ fed.	96.3cde	107.7c	16.2bcd	14.30bc
3 L. Bio. + 80 kg N/ fed.	102.0cde	85.0g	17.1bc	14.3bc
3 L. Bio. + 70 kg N/ fed.	79.3ef	96.3e	13.3cd	16.2abc
4 L. Bio. + 100 kg N/fed.	119.0abc	102.0d	19.9ab	17.16abc
4 L. Bio. + 90 kg N/ fed.	102.0cde	79.3h	17.1bc	13.3c
4 L. Bio. + 80 kg N/ fed.	90.7def	96.7e	15.2bcd	16.2abc
4 L. Bio. + 70 kg N/ fed.	90.7def	113.3b	15.2bcd	19.0ab
5 L. Bio. + 100 kg N/fed.	136.0ab	119.0a	22.8a	20.0a
5 L. Bio. + 90 kg N/ fed.	113.3bcd	102.0d	19.0ab	17.abc
5 L. Bio. + 80 kg N/ fed.	68.0f	102.0d	11.4d	17.1abc
5 L. Bio. + 70 kg N/ fed.	90.7def	79.3h	15.2bcd	13.3c
LSD at 0.05%	26.9	4.5	4.8	5.4

Similar letter(s) in the same column are non-significant statistically at 0.05 level of probability

3.2. Chemical fruit characters

3.2.1. TSS, Total acidity, TSS/TA ratio and vitamin C

The present data in Table (5) showed that the significant deference between levels of bio- and nitrogen fertilization for TSS, Total acidity, TSS/TA ratio and vitamin C in both seasons. The highest values of fruit TSS were recorded by added 5 L. Bio. + 100 or 5 L. Bio. + 80 kg N/ fed., which were 12.37&12.46 for 5 L. Bio. + 100 and 12.4&12.76 for 5 L. Bio. + 80 in the first and second season, respectively. Data in the same table revealed that the highest values of total acidity were recorded by 3 L. Bio. + 90 kg N/fed in first season, while in second season were recorded by 0 L. Bio. + 100 kg N/ fed. (control), respectively. Application 5 L. Bio. + 100 kg N/ fed. to Washington Navel trees recorded the highest values of TSS/TA ratio in two seasons. More than the same treatment was giving the highest values of vitamin C (59.90 and 66.66 mg/100 ml juice) by 5L. Bio. + 100 kg N/ fed., in first and second season, respectively. Our results agreed with those obtained by for TSS [33] on the increasing of bio and nitrogen fertilizers investigated treatments improved the juice TSS %. Washington Navel orange trees. [25] on Valencia orange. [35] reported that application of poultry manure resulted in a higher TSS compared with the control on sweet orange, [26] on Valencia orange and [29] on Eureka lemon fruits. Our results agreed with those obtained for total acidity by [33] reported that the addition on Washington Navel orange of the suitable amount of nitrogen to the trees resulted in increasing the reducing sugars of fruit juice. [34] on Washington Navel orange, [35] in citrus fruits. [29] tested fruit juice chemical character for Eureka lemon. Also, present results agreed with those obtained for vitamin C by [37] reported that the ascorbic acid content in the juice of Nagpur mandarin. [25] on fruit orange Valencia, [26] on Valencia orange and [29] on Eureka lemon fruits.

Table 5: TSS, total acidity, TSS/TA ratio and vitamin C of fruits as affected by bio-fertilizer and nitrogen rates on Washington Navel orange during two seasons

Characters	TSS %		Total acidity (%)		TSS/TA ratio		Vitamin C (mg/100 ml juice)	
Seasons / Treatments	2021/22	2022/23	2021/22	2022/23	2021/22	2022/23	2021/22	2022/23
Cont. 0 Bio.+100 kg N/ fed.	11.50cd	11.33e	0.660d	0.783a	17.42abc	14.58g	52.33ab	54.46de
3 L. Bio. + 100 kg N/ fed.	12.13ab	12.23abcd	0.716bcd	0.676cde	17.01abc	18.08bc	57.70a	58.86bcd
3 L. Bio. + 90 kg N/ fed.	12.20ab	11.86cde	0.800a	0.700bcd	15.28d	16.99cdef	56.33a	54.40de
3 L. Bio. + 80 kg N/ fed.	11.97abc	12.20abcd	0.683bcd	0.650de	17.81a	18.82ab	53.33ab	62.23abc
3 L. Bio. + 70 kg N/ fed.	12.03ab	12.23abcd	0.733abc	0.750ab	16.41abcd	16.34def	54.32ab	59.93bcd
4 L. Bio. + 100 kg N/ fed.	12.20ab	12.06bcd	0.750ab	0.780a	16.27bcd	17.15fg	54.33ab	61.16abc
4 L. Bio. + 90 kg N/ fed.	12.33a	12.36abcd	0.703bcd	0.683cde	17.58ab	18.14bc	49.33ab	54.46de
4 L. Bio. + 80 kg N/ fed.	11.36d	11.80de	0.733abc	0.670cde	15.52d	17.63bcd	58.83a	48.86e
4 L. Bio. + 70 kg N/ fed.	11.73bcd	12.33abcd	0.676cd	0.670cde	17.37abc	18.43ab	54.40ab	56.66cd
5 L. Bio. + 100 kg N/ fed.	12.37a	12.46abc	0.717bcd	0.626e	17.28abc	19.94a	59.90a	66.66a
5 L. Bio. + 90 kg N/ fed.	12.40a	12.76a	0.700bcd	0.703bcd	17.66ab	18.15bc	53.33ab	49.96e
5 L. Bio. + 80 kg N/ fed.	11.76bcd	12.53ab	0.733abc	0.726abc	16.04cd	17.27bcde	45.50b	53.33de
5 L. Bio. + 70 kg N/ fed.	11.73bcd	12.23abcd	0.717bcd	0.776a	16.38abcd	15.76efg	53.30ab	63.30ab
LSD at 0.05%	0.48	0.65	0.069	0.063	1.46	1.71	10.97	6.6037

Similar letter(s) in the same column are non-significant statistically at 0.05 level of probability.

3.2.2. Phenols and sugar

The present data in Table (6) appeared that the significant deference between levels of bio- and nitrogen fertilization for total phenols mg/g fresh weight, total sugars %, reducing sugars % and non-reducing sugars% in 2021/22 and 2022/23 seasons. The highest values of total phenols mg/g fresh weight (mg/g) were recorded by 4 L. Bio. + 100 kg N/fed in first and second seasons respectively. Also, the highest values of total sugars % (9.08 and 9.07%) in first season and second season were obtained by 5 L. Bio. + 100 kg N/fed. Meanwhile, the lowest values obtained from control treatment (7.49%) in both season. Addition of 3L. Bio. + 80 kg N/fed produced the highest values of reducing sugars % in first season while in second season was recorded by (3L. Bio. + 90 kg N/fed) without significant difference between 5 L Bio+100 kg/fed. The highest values of non-reducing sugars% in first season was recorded by (4L. Bio. + 70 kg N/fed), while in second season was recorded by (5L. Bio. + 100 kg N/fed). Our results agreed with those obtained by for phenols. [38] on (*Citrus sinensis*, L.), [39] on ' citrus fruits and [40] of the lemon fruit. Also, our results agreed with those obtained by for total sugars [33] on Washington Navel orange, [34] on Washington Navel orange and [36] in citrus fruits. [41] reported that the maximum increase of quality parameters like total sugar were observed in treatment farmyard manure (40 kg/ tree). [29] reported that the total sugars in Eureka lemon fruits.

Table 6: Total phenols and sugars % as affected by bio-fertilizer and nitrogen rates on Washington Navel orange during two seasons

Characters	Total phenols mg/g fresh weight		Total sugars%		Reducing sugars %		Non-reducing sugars%	
Seasons / Treatments	2021/22	2022/23	2021/22	2022/23	2021/22	2022/23	2021/22	2022/23
Cont. 0 Bio.+100 kg N/fed.	0.474ab	0.425bc	7.49c	7.49c	3.26 d	3.26 c	4.24d	4.23d
3 L. Bio. + 100 kg N/ fed.	0.448ab	0.437abc	8.89a	8.71ab	3.55ab	3.45ab	5.35ab	5.26abc
3 L. Bio. + 90 kg N/ fed.	0.484ab	0.474abc	8.62ab	8.62ab	3.49abc	3.52a	5.13bc	5.09bc
3 L. Bio. + 80 kg N/ fed.	0.518ab	0.524ab	8.37b	8.60ab	3.56a	3.44ab	4.80c	5.17abc
3 L. Bio. + 70 kg N/ fed.	0.481ab	0.501abc	8.36b	8.31b	3.52ab	3.40abc	4.83c	4.91c
4 L. Bio. + 100 kg N/ fed.	0.560a	0.531a	8.97a	9.09a	3.51ab	3.44ab	5.47ab	5.65a
4 L. Bio. + 90 kg N/ fed.	0.441ab	0.460abc	9.03a	9.00a	3.45abc	3.46ab	5.57ab	5.54ab
4 L. Bio. + 80 kg N/ fed.	0.511ab	0.513ab	8.83ab	8.68ab	3.39bcd	3.36bc	5.44ab	5.32abc
4 L. Bio. + 70 kg N/ fed.	0.444ab	0.453abc	8.95a	8.80ab	3.34cd	3.38abc	5.61a	5.42abc
5 L. Bio. + 100 kg N/ fed.	0.412b	0.406c	9.08a	9.07a	3.53ab	3.43ab	5.55ab	5.64a
5 L. Bio. + 90 kg N/ fed.	0.485ab	0.491abc	8.94a	8.87ab	3.50abc	3.46ab	5.44ab	5.41abc
5 L. Bio. + 80 kg N/ fed.	0.419b	0.434abc	8.96a	8.99a	3.50abc	3.48ab	5.47ab	5.51ab
5 L. Bio. + 70 kg N/ fed.	0.412b	0.433abc	8.97a	8.69ab	3.44abc	3.44ab	5.53ab	5.25abc
LSD at 5%	0.123	0.100	0.51	0.55	0.17	0.15	0.47	0.52

Similar letter(s) in the same column are non-significant statistically at 0.05 level of probability

4. Conclusion

a combination of chemical and bio fertilizer is not only beneficial in improving the properties and environment of soils, but also promotes flowering, fruit set %, fruit yield and fruits chemical properties in orange. Here, our work confirmed that was helpful in increasing citrus yield and improving quality.

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