Asian Journal of Agricultural and Horticultural Research

2(2): 1-13, 2018; Article no.AJAHR.44460
ISSN: 2581-4478

Impact of Nitrogen Application Timing and Boron-Zinc Spray on "Fuerte" Avocado

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Authors' contributions

This work was carried out in collaboration between all authors. Author RGS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors IEES and HAAK managed the analyses of the study. Author AER managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJAHR/2018/44460
Editor(s):
(1) Dr. Magdalena Valsikova, Professor, Department of Vegetables Production, Faculty of Horticulture and Landscape Engineering, Slovak University of Agriculture (SUA), Nitra, Slovakia.
Reviewers:
(1) Sayan Sau, Bidhan Chandra Krishi Viswavidyalaya, India.
(2) Dennis Simiyu Wamalwa, Maseno University, Kakamega School, Kenya.
Complete Peer review History: http://prh.sdiarticle3.com/review-history/26757

Original Research Article

Received 19 July 2018
Accepted 04 October 2018
Published 23 October 2018

ABSTRACT

This study was carried out throughout two successive seasons of 2015 and 2016 at Horticulture Research Station at El-Kanater El-Khayria, Qalyubeia Governorate on 20-year-old avocado trees (*Persea americana* Mill.) "Fuerte" cultivar grafted on Dayouk rootstock and irrigated through farrow (surface) irrigation system. In this sequence (N_1) as the control or untreated trees and other trees were treated with four treatments of different addition times of nitrogen soil fertilization (N_2, N_3, N_4, and N_5) all only once and once with boron and zinc as foliar spraying in concentrations (1, 2 and 3 g/L) beside combination between them. Nitrogen fertilization rated 1200 g /tree in 3 times as (NH_4No_3) 33. 5%. Boron was used as sulaphate boron (17, 5%) and zinc was used as sulphate zinc (34%) where each treatment was sprayed independently or in combination three times during (October, January, April). Pollen germination, fruit set as well as yield, fruit weight, flesh weight, oil content percentage and vitamin C were determined to assess the effect of the treatments. The obtained results showed that nitrogen soil application time and boron and zinc foliar spraying were significantly affected on improving all the tested parameters compared with control trees. The study

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also showed that, nitrogen soil application time N_2 with boron and zinc combination at 1g/L/tree was more effective than the other treatments and gave significantly the highest values in comparison of other tested treatments in both seasons of study.

Keywords: 'Fuerte' Avocado; nitrogen; boron; zinc; fruit set; fruit quality and oil content.

1. INTRODUCTION

The avocado (*Persea americana* Mill.) belongs to family Lauraceae with its three races i.e. West Indian, Guatemalan and Mexican [1] adapted to a wide range of soil and climatic conditions. Avocado which has been referred to as the most nutritious of all fruits [2], has gained worldwide recognition and significant volume in international trade. Although relatively new in international commerce, this unique fruit has been appreciated and utilized for at least 9000 years in and near its center of origin in Meso-America [3]. Avocado is a relatively new crop in areas of the world outside its native range in the American tropics. In 2013, world production of avocados was 4.7 million tons, with Mexico alone accounting for 32% (1.47 million tons) of the total production. Other major producers include Dominican Republic, Colombia, Peru and Indonesia, together totaling 1.26 million tons or 28% of world production FAOSTAT of the United Nations 2013. "Fuerte" is one of the most common avocado cultivar in the international market and accounts for about 55% of the production in Mexico and California, beside it is important in other countries [4,5].

In Egypt, the avocado was grown in limited areas in El-Delta, in 50s and 60s of the previous century. Only Fuertre and Dayouk were grown in these areas until recent were new areas as El-Nubaria, Ismailia and El-Khatatba started to be grown with avocado.

“Fuerte” the most spread cultivar is a Mexican _ Guatemalan hybrid, Tree is large with spreading crowns; leaves have aniseed smell when crushed, red flecking on wood of new shoots; flower Group B, fruit pyriform with distinct neck but variable ranging from elongated with long narrow neck to dumpy with short broad neck, medium to large size weighing 170–500 g, skin thin, green, medium gloss, supple leathery texture, pimpled surface, seed size is medium to large, conical with pointed apex, early maturing with pale yellow flesh, 75–77% recovery, excellent quality with flavoursome, nutty after-taste, good on-tree storage, but short shelf-life when ripe the chemical composition of avocado depends on the cultivar and stage of ripening [6].

In Egypt, “Fuerte” is harvested all year round but its' main season is from October to December. Main problems facing avocado plantations are slow to reach production, low yields in cooler climates with a marked tendency for erratic cropping and sensitivity to low temperatures during flowering and fruit set [7].

Nitrogen seems to be the most important element in avocado nutrition. Deficiencies of nitrogen in avocado result in small, pale leaves, early leaf drop, and smaller and fewer fruits [8]. In addition, nitrogen deficient trees were found to be more susceptible to frost damage [9].

Boron is essential for pollen germination, for successful growth of the pollen tube through the stigma, style and ovary to the ovule [10].

On worldwide basis zinc (Zn) is a very critical microelement because the avocado is very susceptible to their deficiency. Symptoms of Zn deficiency are observed in acid soils from which it is easily leached at a low pH and in calcareous soils in which it is fixed in unavailable forms [11].

Earlier numerous fertilization regimes were tested by several scientists both with major nutrient nitrogen and micro nutrient B and Zn [12,13,14,15] in avocado and considering their work as review, the present experiment was conducted to illustrate the impact of N, B and Zinc at different doses on 'Fuerte' avocado in Egypt condition.

2. MATERIALS AND METHODS

This investigation was carried out through the two successive seasons of 2015 and 2016 on 20 year old avocado trees (*Persea americana, Mill.*) "Fuerte" cultivar grown in the experimental orchard of the Horticulture Research Station located in El-Qanater El-Khayreia, Qalubia Governorate, Egypt between latitudes 22-32 north and longitudes 25-37 east. Trees were planted at 7x7 meters (86 trees/ feddan. One hundred and fifty Feurte cultivar trees grafted on Dayouk rootstock were chosen for this study.

The chosen trees for the investigation were uniform in their vigor, size, shape and disease free, grown on loamy clay soil and irrigated with a farrow (surface) irrigation system. Trees were subjected to normal cultural practices recommended by the Ministry of Agriculture except for the treatments of this investigation with fixed quantity of P and K fertilization as (1 kg super phosphate and 0.5 kg potassium sulphate). Experimental design followed the complete randomized block design.

The following regimes were conducted each on three separate trees (each acting as a replicate).

Considered fertilization regimes:

Nitrogen fertilization regimes:

All trees used in this investigation were fertilized by broadcast with 1200 gm N as the recommendation of ministry of Agriculture (the fertilizer ammonium sulfate 20% N was used). Five regimes were considered based on percentage and time of application. The considered regimes were:

N_1: Control as farm's regime. Fertilizer was split into 3 doses i.e. November 400 g/tree (33.3%), 400 g/tree (33.3%) in January and 400 g/tree(33.3%) in May.
N_2: Fertilizer was split into 3 doses 240g/tree (20%) in (January), 600 g/tree (50%) in (May) and 360 g/tree (30%) in (August).
N_3: 600 g/tree (50%) in (January), 360 g/tree (30%) in (May) and 240 g/tree (20%) in (August).
N_4: 600 g/tree (50%) in (January) and 600 g/tree (50%) in (May).
N_5: 600 g/tree (50%) in (May) and 600 g/ tree (50%) in (August).

Boron and zinc regimes:

B: boron the product boron sulphate (17. 5% B) was used in three concentrations (1, 2, 3 g/L) / tree i.e. (175, 350, 525 ppm) respectively as B_1, B_2 and B_3.
Zn: zinc the product zinc sulphate (34.5% Zn) was used in the same concentrations (1, 2, 3 g/L) / tree (345, 690, 1035 ppm) respectively as Zn_1, Zn_2 and Zn_3.
B+Zn: combination between them as (B_1+Zn_1, B_2+Zn_2 and B_3+Zn_3) in (1, 2, 3 g/L) / tree.

Treatments were sprayed with a power operated sprayer until run-off each for three times, the first at the beginning of flower bud induction (October), the second spray was at bud burst (January) and the last and third one was at anthesis (April).

Fifty treatments were performed each on 3 separate trees as follows: N_1, N_1+B_1, N_1+B_2, N_1+B_3, N_1+Zn_1, N_1+Zn_2, N_1+Zn_3, N_1+B_1+ Zn_1, N_1+B_2+ Zn_2 and N_1+B_3+ Zn_3 and the same way with the treatments N_2, N_3, N_4 and N_5.

The following parameters were assessed to evaluate the comparative effects of the conducted treatments.

2.1.1 <u>Pollen grains germination percentage</u>

Five inflorescences were chosen randomly on each of the considered trees to assess comparative effects of conducted treatments on this parameter and the fruiting parameters. To calculate pollen germination (%), pollens were collected during anthesis stage. Flower in the male stage of the reproductive cycle were collected in paper bags then transferred to the laboratory. After anther dehiscence when pollen shed they were collected and incubated in Petri dishes on a medium containing 15% sucrose and 0.8% agar [16]. Pollen germination was recorded after 6 hours as the percentage of germinated pollen in a total of 500 grains from different areas of plat. Each pollen sample was replicated three times. Pollen was considered to have germinated if pollen tube length was at least twice as long as the diameters of grain, samples were observed by Optical microscope (410v- Leica Micro Star IV) – USA.

2.1.2 <u>Yielding parameters</u>

In both seasons, fruit set was determined by marking five flowering branch ends around the circumference of each treated trees two weeks after full bloom. On the last week of August just at harvest time the number of fruit/ branch was counted to estimate the final fruit set

$$\text{Final fruit set (\%)} = \frac{\text{Number of fruit per branch}}{\text{Number of initial flower}} \times 100$$

At harvest, fruits of each tree were picked, counted and weighed with a digital balance in Kgs. The yield (Kg) was determined as

$$\text{Yield (Kg)} = \frac{\text{Total number of fruit /tree} \times \text{ Average fruit weight (gm)}}{1000}$$

2.1.3 Fruit quality parameters

Mature Fuerte fruits were harvested at the 3rd week of September when fruits reached maturity [17]. Samples of five representing fruits from each considered tree were harvested, cleaned packed in carton boxes in one layer and transferred to laboratory for assessing both physical and quality parameters.

2.1.3.1 Physical parameters

As fruit physical parameters, fruit weight (g) and flesh weight (g) were determined using digital balance.

2.1.3.2 Chemical parameters

The fatty acid methyl esters were prepared using solution of methylalcohol, benzene, 2,2-dimethoxy propane, sulphuric acid (37:20:5:2 v/v/v/v) and n. heptane was used for separation of methyl esters as described by (Garces and Marcha 1993). Fatty acids were determined by comparison of retention time of the gas chromatographic peaks with these of commercial free fatty acid methyl ester standards, then automatically computed as a percentage by the data processor (Chrom card) from the ratio of individual peak area to the total peaks area of fatty acids. Vitamin C as mg ascorbic acid/100 gm fruit weight was determined as 100 gm fruit weight and 100 ml oxalic acid (6% concentration) then 10 ml juice is taken in cup and complete to 100 ml with oxalic acid (3% concentration) finally 10 ml from this solution is taken and put drops of 2, 6 dichloro phenol indophenol according to AOAC, [18].

2.2 Statistical Design and Data Analysis

Experimental design followed the complete randomized block design. The obtained data was subjected to factorial analysis according to Snedecor and Cochran [19]. Attained means were compared by using New LSD method at 5%.

3. RESULTS AND DISCUSSION

3.1 Fruit set parameters

Pollen grains germination (%): Data presented in Table (1) showed that pollen germination percentage significantly varied with adopt treatments. With respect to nitrogen regimes, on the average the highest significant percentage attained was dedicated to (N_2) treatment amounting to (77.36 &77.74 %) for both seasons respectively whereas, the significantly the lowest percentage was due to (N_1) treatment (control) amounting to (59.04 & 59.23 %) for both seasons respectively.

With respect to the foliar spray treatments on the average the applied treatments increased this parameter in the first season significantly compared with control except for (B_3, Zn_3 & B_3+Zn_3) treatments whose effects were statistically at par with control. In the second season however, treatments (B_1, Zn_2, Zn_3 & B_3+Zn_3) did not induce any significant effect compared with control. The other treatments resulted in significantly higher percentages. Highest significant germination percentage was attributed to (B_1+Zn_1) treatment in both seasons amounting to (76.59 & 77.55 %) in both seasons respectively.

Interaction between the two main factors was significant. The highest values of pollen germination percentage (84.33 & 86.13 %) and (84.50 & 84.17 %) in both of seasons respectively were dedicated to (N_2+ B_1+ Zn_1) and (N_3+ B_1+ Zn_1). While the lowest percentage (553.57 & 55.27 %) were due to ($N_{1)}$ and (N_1+B_3) treatments respectively in the first season. While in the 2nd season they were (53.27 & 54.63 %) for both with (N_1+Zn_3) and (N_1+B_3) respectively. The obtained results are in line with the finding of [20] who proved that effect of combination of these nutrients positively affected pollen germination. Storey [21] reported that boron plays an important role in pollen germination and pollen tube growth.

3.2 Fruit Set (%)

Table (2) showed that other nitrogen treatments in the both seasons were more effective significantly than control (N_1) which resulted the lowest percentages (50.183 & 50.08 %) respectively compared with (N_2) treatment which recorded the highest significant values (54.59 & 55.69 %) for both seasons respectively. With respect to foliar treatments, on the average their effects varied. Highest significant percentage in both seasons were attributed to B1Zn1 in both seasons amounting to 55.39 & 57.36 respectively and B1 treatment in the first season (53.94%) while (B_3+Zn_3) and (Zn_3) recorded the lowest values (50.75 & 49.87 %) and (49.87 & 49.77 %) for both seasons respectively.

Furthermore, interaction between nitrogen soil application regimes and boron and zinc foliar spraying application during both seasons was significant. Data showed that the combined (N_2+B_1+Zn_1) induced the highest fruit set percentage amounting to (57.2 & 60.37%) in both seasons respectively. These findings are in agreement with [22] who found that increase in fruit set due to boron might be attributed to its role in maintaining high pollen viability and germination. Also it seems that the improvement in fruit set percentage could be explained as a result of increase pollen tube elongation due to boron treatments [23,24]. Khayyat et al. [25] on date palm found that (N, P, K and Zn) spray application can improve fruit set, yield and fruit size without thinning. In addition, zinc is involved in protein synthesis, influence on electron transfer reaction including those in the Kreb's cycle and subsequently on energy production in the plant and also directly involved in the synthesis of indole acetic acid [11].

3.3 Yield (Kg/tree)

It is obvious from data in Table 3 that in both seasons of study on the average yield significantly varied in response to nitrogen soil application regimes. The highest significant yield (106.60 & 107.33 kg) in both seasons respectively was attributed to (N_2), while significantly the lowest yield (74.49 & 75.42 kg) was obtained from (N_1) treatment as control in both of seasons.

On the other hand, yield of avocado varied on the average due to foliar treatments. Supreme crop was attributed to the (B_1+Zn_1) treatment in both seasons (102.66 & 104.59 kg). Where as both (Zn_3) and (B_3+Zn_3) resulted in statistically the least crop in both seasons amounting to (87.82 & 89.01 kg) and (82.58 & 84.71 kg) respectively.

Interaction between the studied factors was statistically significant which revealed to that nitrogen soil application and boron, zinc foliar spraying act dependently in this concern. The highest yield (113.9 & 116.1 kg) was attributed to from (N_2+B_1+Zn_1) treatment in both seasons respectively, while the lowest yield (69.2 & 64.4 kg) and (68.1 & 65.7 kg) were obtained from (N_1+B_3+ Zn_3) and (Zn_3) treated in both seasons, respectively. Enhancements in crop due to the afore mentioned treatments are basically due to their effects on increasing both the pollen grain germination percentage and fruit set percentage .The available reports concerning the effect of nitrogen application time, boron and zinc foliar spraying on avocado yield are in agreement with the results of [26] on avocado and [27] on guava, where they found that foliar sprays with either B or Zn have immense potential in improving tree yield.

3.4 Physical Fruit Parameters

3.4.1 Fruit weight (g)

Table 4 indicated that in both of seasons on the average all considered N regimes significantly increased the average fruit weight than control. Highest significant effect was due to (N_2) treatment (298.9 & 306.6 g). While, (N_1) control showed the lowest values (262.5 & 264.4 g) for both seasons respectively.

With regards to boron and zinc foliar spraying treatments on the average, (B_1+Zn_1) induced the highest significant fruit weight in both seasons (286.7 & 305.5 g) respectively. While both (Zn_3) and (B_3+Zn_3) treatments showed statistically the lowest values (268.0 & 266.1 g) and (262.3 & 259.4 g) respectively.

On other hand, interaction between nitrogen soil application and foliar spraying of boron and zinc was significant. Data cleared that fruit weight also attained significantly the highest magnitude for. (N_2+B_1+Zn_1) treatment resulted (308.2 & 349.0 g) respectively in both tested seasons. Whereas control (N_1) in both seasons with (Zn_3) and (B_3+Zn_3) treatments induced the least fruit weight (255.3 & 250.0 g) and (255.5 & 253.3 g). These results are in general concurrence with [28] on sapota trees and [29,13] on avocado trees who found that foliar sprays of micro nutrients to avocado and sapota have improved fruit weight and quality of fruit.

3.5 Flesh Weight (g)

Data in Table (5) showed that flesh weight was significantly affected by applied nitrogen regimes on the average. Significantly the heaviest flesh weight was attributed to (N_2) treatment (249.0 & 256.7 g). Whereas, control in both seasons and (N_5) treatment in the second one showed the lowest flesh weighted.

Concerning boron and zinc foliar spraying treatments, on the average significantly the heaviest flesh weight recorded was (244.3 & 264.7 g) was due to (B_1+Zn_1). Whereas, ($B_{3+}Zn_3$) in both seasons (206.1 & 195.9 g) and (Zn_3) (208.5 g) in the first season showed significantly the lowest values.

Table 1. Effect of nitrogen soil application time and B-Zn foliar spray on pollen germination percentage of 'Fuerte' Avocado

Pollen germination (%)											
1st season											
(A)	**B_0+Zn_0**	**Nitrogen soil & B & Zn foliar spraying treatments**									**Mean (A)**
		B_1	**B_2**	**B_3**	**Zn_1**	**Zn_2**	**Zn_3**	**B_1+Zn_1**	**B_2+Zn_2**	**B_3+Zn_3**	
N_1	53.57	58.47	56.27	55.27	57.20	58.83	55.57	69.43	65.27	60.50	**59.04**
N_2	71.50	80.97	79.43	76.10	78.30	79.40	70.43	84.33	80.73	72.43	**77.36**
N_3	69.20	78.63	74.67	70.53	71.20	70.37	69.10	84.50	76.60	67.97	**73.28**
N_4	65.30	70.43	69.17	67.23	68.33	65.60	62.20	76.57	70.63	63.23	**67.87**
N_5	60.03	64.63	61.67	58.07	62.57	59.23	57.60	68.13	63.47	56.20	**61.16**
Mean (B)	**63.92**	**70.63**	**68.24**	**65.44**	**67.52**	**66.69**	**62.98**	**76.59**	**71.34**	**64.07**	
New LSD at 5%		**(A) = 1.42**		**(B) = 2.01**		**(AxB) = 4.49**					
2nd season											**Mean (A)**
N_1	55.40	59.50	56.30	54.63	57.97	58.37	53.27	71.70	68.13	57.03	**59.23**
N_2	73.20	82.37	80.63	74.13	80.73	80.17	68.50	86.13	80.90	70.60	**77.74**
N_3	70.57	79.17	74.10	68.97	70.57	69.50	66.10	84.17	73.40	63.13	**71.97**
N_4	65.03	73.27	65.63	62.87	65.53	61.70	59.17	75.10	65.37	58.23	**65.19**
N_5	58.40	66.60	57.63	54.23	59.13	56.07	54.77	70.63	65.13	52.83	**59.54**
Mean (B)	**64.52**	**72.18**	**66.86**	**62.97**	**66.79**	**65.16**	**60.36**	**77.55**	**70.59**	**60.37**	

New LSD at 5%; (A) = 1.37; (B) = 1.94; (AxB) = 4.34

Table 2. Effect of nitrogen soil application time and B-Zn foliar spray on fruit set percentage of 'Fuerte' Avocado

Fruit set (%)											
1st season											
(A)	**Nitrogen soil & B & Zn foliar spraying treatments**										
	B_0+Zn_0	**B_1**	**B_2**	**B_3**	**Zn_1**	**Zn_2**	**Zn_3**	**B_1+Zn_1**	**B_2+Zn_2**	**B_3+Zn_3**	**Mean (A)**
N_1	51.13	53.10	51.17	49.23	51.47	49.57	48.00	54.17	52.13	48.37	**50.83**
N_2	53.67	55.67	54.90	53.33	54.43	55.77	52.43	57.20	55.23	53.23	**54.59**
N_3	52.60	54.13	52.80	51.70	53.37	52.37	51.30	55.10	53.53	50.77	**52.77**
N_4	51.17	53.07	52.33	51.70	53.23	52.17	51.57	55.50	53.60	50.73	**52.51**
N_5	51.97	53.73	50.40	50.23	54.03	53.67	50.53	54.97	53.70	50.63	**52.39**
Mean (B)	**52.11**	**53.94**	**52.32**	**51.24**	**53.31**	**52.71**	**50.77**	**55.39**	**53.64**	**50.75**	
New LSD at 5%		**(A) = 1.23**		**(B) = 1.74**		**(AxB) = 3.89**					

	Fruit set (%)										
	2nd season										**Mean (A)**
N_1	50.13	51.57	50.57	48.17	50.43	48.70	47. 37	55.27	51.17	47.40	**50.08**
N_2	55.70	57.13	56.30	52.67	56.50	56.33	51.67	60.37	57.47	52.73	**55.69**
N_3	53.57	54.97	54.50	50.10	55.77	53.73	50.47	57.80	52.10	50.43	**53.34**
N_4	52.50	54.63	53.47	51.43	54.40	53.03	50.90	56.57	52.97	48.90	**52.88**
N_5	51.57	52.60	51.63	49.20	53.73	52.40	48.43	56.80	53.77	49.47	**51.96**
Mean (B)	**52.69**	**54.18**	**53.29**	**50.31**	**54.17**	**52.84**	**49.77**	**57.36**	**53.49**	**49.78**	

New LSD at 5%; (A) = 1.36; (B) = 1.92; (AxB) = 4.30

Table 3. Effect of nitrogen soil application time and B-Zn foliar spray on yield (Kg/tree) of 'Fuerte' Avocado

	Yield (kg)										
	1st season										
(A)	**Nitrogen soil & B & Zn foliar spraying treatments**										**Mean (A)**
	B_0+Zn_0	**B_1**	**B_2**	**B_3**	**Zn_1**	**Zn_2**	**Zn_3**	**B_1+Zn_1**	**B_2+Zn_2**	**B_3+Zn_3**	
N_1	73.4	79.1	76.0	72.8	76.2	71.6	68.1	83.6	74.5	69.2	**74.49**
N_2	104.8	109.0	106.8	103.4	108.0	108.4	101.3	113.9	110.4	99.7	**106.60**
N_3	101.0	106.4	104.8	100.7	104.7	100.8	95.1	108.3	107.6	93.8	**102.47**
N_4	99.3	103.7	101.1	95.9	101.4	98.0	92.8	105.2	100.3	91.1	**98.92**
N_5	93.8	95.9	95.1	90.6	94.1	91.5	87.6	100.8	96.0	85.2	**93.11**
Mean (B)	**94.49**	**98.85**	**96.80**	**92.71**	**96.93**	**94.08**	**89.01**	**102.66**	**97.82**	**87.82**	
New LSD at 5%	**(A) = 1.60**			**(B) = 2.27**			**(AxB) = 5.07**				
	2nd season										**Mean (A)**
N_1	76.1	82.7	77.1	69.0	80.0	74.6	65.7	85.2	79.2	64.4	**75.42**
N_2	105.9	112.6	110.1	101.4	110.4	109.2	98.1	116.1	113.8	95.2	**107.33**
N_3	102.7	109.7	103.9	94.0	102.3	98.0	90.9	113.5	108.1	87.2	**101.06**
N_4	97.5	104.0	97.1	90.6	100.9	93.1	87.0	106.8	98.1	85.0	**96.04**
N_5	89.0	97.0	94.9	86.0	96.0	87.9	81.7	101.3	95.1	80.8	**91.01**
Mean (B)	**94.27**	**101.25**	**96.65**	**88.23**	**97.96**	**92.58**	**84.71**	**104.59**	**98.90**	**82.58**	

New LSD at 5%; (A) = 1.55; (B) = 2.19; (AxB) = 4.90

Table 4. Effect of nitrogen soil application time and B-Zn foliar spray on fruit weight (g) of 'Fuerte' Avocado

Fruit weight (g)											
1st season											
(A)	Nitrogen soil & B & Zn foliar spraying treatments										Mean (A)
	B_0+Zn_0	B_1	B_2	B_3	Zn_1	Zn_2	Zn_3	B_1+Zn_1	B_2+Zn_2	B_3+Zn_3	
N_1	258.0	266.2	263.5	257.8	265.2	262.3	255.3	271.3	269.5	255.5	**262.5**
N_2	298.7	303.5	305.6	297.4	301.6	300.5	289.5	308.2	299.0	284.7	**298.9**
N_3	265.0	281.4	275.2	270.6	279.4	279.2	270.2	300.4	289.1	268.5	**277.9**
N_4	262.4	268.5	266.7	262.3	265.6	268.4	261.9	275.2	262.9	262.4	**267.9**
N_5	263.2	266.1	269.9	263.9	268.0	270.1	263.0	278.3	274.1	259.4	**265.3**
Mean (B)	**269.5**	**277.1**	**276.2**	**270.4**	**276.0**	**276.1**	**268.0**	**286.7**	**278.9**	**266.1**	
New LSD at 5%	**(A) = 1.482**			**(B) = 2.100**			**(AxB) = 4.695**				
2nd season											Mean (A)
N_1	266.1	270.2	268.6	255.1	266.4	266.7	250.0	277.1	270.6	253.3	**264.4**
N_2	307.3	311.1	309.5	297.3	310.2	307.4	281.3	349.0	323.5	269.1	**306.6**
N_3	271.7	284.5	282.0	268.1	282.2	282.0	270.4	304.4	290.6	264.3	**280.0**
N_4	269.2	280.3	282.0	260.4	276.9	280.1	260.5	298.7	288.4	258.8	**275.5**
N_5	255.4	271.1	265.0	255.2	268.3	270.1	249.5	298.2	279.6	251.4	**266.4**
Mean (B)	**273.9**	**283.4**	**281.4**	**267.2**	**280.8**	**281.3**	**262.3**	**305.5**	**290.5**	**259.4**	

New LSD at 5%; (A) 1.272; (B) = 1.801; (AxB) = 4.022

Table 5. Effect of nitrogen soil application time and B-Zn foliar spray on flesh weight (g) of 'Fuerte' Avocado

Flesh weight (g)											
1st season											
(A)	Nitrogen soil & B & Zn foliar spraying treatments										
	B_0+Zn_0	B_1	B_2	B_3	Zn_1	Zn_2	Zn_3	B_1+Zn_1	B_2+Zn_2	B_3+Zn_3	Mean (A)
N_1	203.1	210.0	210.6	201.2	212.9	211.8	193.3	228.1	217.7	194.6	**208.3**
N_2	251.8	257.2	255.6	243.3	257.0	249.8	234.6	262.9	249.3	228.1	**249.0**
N_3	213.9	226.0	224.0	211.0	225.9	223.4	211.6	258.3	230.0	205.8	**223.0**
N_4	211.0	215.6	209.9	200.1	219.3	220.3	202.8	236.9	219.1	200.2	**213.5**
N_5	205.8	219.0	212.5	201.5	215.8	217.3	200.2	235.1	215.1	201.6	**212.4**
Mean (B)	**217.1**	**225.6**	**222.5**	**211.4**	**226.2**	**224.5**	**208.5**	**244.3**	**226.2**	**206.1**	
New LSDat 5%	**(A) = 1.374**			**(B) = 2. 743**			**(AxB) = 5.046**				

	Flesh weight (g)										
	2nd season										Mean (A)
N_1	203.0	220.3	216.5	190.2	220.8	222.1	190.8	248.2	228.4	187.3	**212.8**
N_2	257.2	268.0	262.1	235.4	268.9	263.1	220.8	316.2	270.3	205.0	**256.7**
N_3	220.0	235.2	238.0	204.1	237.2	238.1	204.1	265.1	242.5	200.0	**228.4**
N_4	211.9	228.4	223.9	197.1	230.8	230.3	199.1	254.8	234.0	194.1	**220.4**
N_5	209.7	223.5	219.0	195.4	225.0	220.3	190.9	239.2	223.3	192.9	**213.9**
Mean (B)	**220.4**	**235.1**	**231.9**	**204.5**	**236.5**	**234.8**	**201.1**	**264.7**	**239.7**	**195.9**	

New LSDat 5%; (A) = 1. 543; (B) = 2. 692; (AxB) = 5. 310

Table 6. Effect of nitrogen soil application time and B-Zn foliar spray on oil content percentage of 'Fuerte' Avocado

	Oil content (%)										
	1st season										
(A)	Nitrogen soil & B & Zn foliar spraying treatments										**Mean (A)**
	B_0+Zn_0	B_1	B_2	B_3	Zn_1	Zn_2	Zn_3	B_1+Zn_1	B_2+Zn_2	B_3+Zn_3	
N1	14.44	15.21	15.18	15.13	14.53	14.72	14.70	15.61	15.54	15.42	**15.05**
N2	15.27	15.75	15.42	15.34	15.43	15.63	15.43	16.33	16.22	16.14	**15.70**
N3	15.20	15.44	15.24	15.22	15.27	15.35	15.22	15.82	15.54	15.28	**15.36**
N4	15.17	15.25	15.19	15.18	15.23	15.32	15.19	15.62	15.37	15.21	**15.27**
N5	14.72	15.25	15.21	15.15	14.94	15.26	14.86	15.59	15.31	15.16	**15.15**
Mean(B)	**14.96**	**15.38**	**15.25**	**15.20**	**15.08**	**15.26**	**15.08**	**15.79**	**15.60**	**15.44**	
New LSD at 5%		**(A) = 0. 158**			**(B) = 0. 130**			**(AxB) = 0. 290**			
	2nd season										**Mean(A)**
N1	14.63	15.15	15.17	15.10	14.73	14.65	14.63	15.75	15.63	15.31	**15.08**
N2	15.54	15.82	15.59	15.55	15.65	15.67	15.44	16.49	16.50	16.23	**15.85**
N3	15.28	15.64	15.43	15.30	15.47	15.63	15.29	15.84	15.55	15.28	**15.47**
N4	15.10	15.34	15.18	15.17	15.27	15.42	15.18	15.70	15.38	15.23	**15.30**
N5	14.64	15.16	15.21	15.11	15.14	15.16	14.73	15.56	15.12	15.06	**15.09**
Mean (B)	**15.04**	**15.42**	**15.32**	**15.25**	**15.25**	**15.31**	**15.05**	**15.87**	**15.64**	**15.42**	

New LSD at 5%; (A) = 0.108; (B) = 0.175; (AxB) = 0.320

Table 7. Effect of nitrogen soil application time and B-Zn foliar spray on vitamin C (mg/100g) content of 'Fuerte' Avocado

	Vitamin C (mg/100 g)										
	1st season										
(A)	Nitrogen soil & B & Zn foliar spraying treatments										
	B_0+Z_0	B_1	B_2	B_3	Zn_1	Zn_2	Zn_3	B_1+Zn_1	B_2+Zn_2	B_3+Zn_3	Mean (A)
N_1	10.20	10.56	10.66	10.16	10.66	10.66	10.06	10.86	10.70	10.13	**10.47**
N_2	10.56	10.76	10.83	10.36	10.86	11.06	10.20	11.63	10.76	10.43	**10.75**
N_3	10.46	10.63	10.56	10.33	10.73	10.76	10.13	10.96	10.66	10.20	**10.54**
N_4	10.06	10.56	10.56	10.20	10.70	10.50	10.13	10.83	10.66	10.03	**10.42**
N_5	9.86	10.03	10.03	9.80	9.96	9.96	9.63	10.13	9.86	9.33	**9.86**
Mean (B)	**10.23**	**10.51**	**10.53**	**10.17**	**10.58**	**10.59**	**10.03**	**10.88**	**10.53**	**10.02**	
New LSD at 5%		**(A) = 0. 676**		**(B) = 0. 955**		**(AxB) = 2.013**					
	2nd season										**Mean(A)**
N_1	9.63	9.76	10.06	9.33	10.13	9.93	9.46	10.86	10.13	9.50	**9.88**
N_2	10.76	10.73	10.53	9.66	10.46	10.86	9.56	11.13	10.46	9.46	**10.36**
N_3	10.50	10.56	10.43	9.53	10.03	10.10	9.36	10.86	10.03	9.46	**10.09**
N_4	9.06	10.00	9.63	9.03	9.86	10.03	9.00	10.43	9.66	8.76	**9.55**
N_5	9.06	9.46	9.20	8.90	9.63	9.76	8.70	10.16	9.46	8.56	**9.29**
Mean (B)	**9.80**	**10.10**	**9.97**	**9.29**	**10.02**	**10.14**	**9.22**	**10.69**	**9.95**	**9.15**	

New LSD at 5%; (A) = 0. 726; (B) = 1. 026; (AxB) = 2.129

Interaction between the two main factors was significant. The highest magnitude of flesh weight in both of seasons was dedicated to (N_2+ B_1+Zn_1). The obtained results are in line with the finding of Kumar and Verma [30] on litchi.

3.6 Chemical Fruit Characters

3.6.1 Oil content (%)

Oil content as affected by conducted treatments is presented in Table (6). Data showed that on the average (N_2) treatment resulted in the highest significant oil content (15.70 & 15.85 %) for both considered seasons respectively. On the contrary showed (N_1) induced significantly the lowest content amounting to (15.05 & 15.08 %) for both seasons respectively with insignificant differences from (N_5). As for average effect of foliar treatments, (B_1+Zn_1) treatment showed the highest significant oil content amounting to (15.79 & 15.87 %) for both seasons respectively. Whereas, unsprayed trees bore fruits with significantly the lowest oil content (14.96 & 15.04 %) for both considered seasons respectively). Differences from (Zn_3) treatment were insignificant. Interaction data were significant. Data showed that highest oil content was attributed to (N_2+B_1+Zn_1) and (N_2+ B_2+Zn_2) treatments with insignificant differences between them .While the lowest content was attributed to N_1& no spray treatment in both seasons.

These results are in the line with agree with Abou et al. [31] on avocado and Desouky [32] on olive who found those nitrogen fertilization and micro nutrients increased oil content in fruits. However this result in no agreement with those of Abdel-Karim et al. [26] who illustrated that there was no significant different were observed in fat percentage.

3.6.2 Vitamin C (mg/100 g)

It's obvious from Table (7) that (N_2) recorded the highest fruit vitamin C content in both of seasons (10.75 & 10.36 mg/100g).Whereas, (N_5) treatment showed the lowest magnitudes. As for the average effects of spraying treatment, as (B_1+Zn_1) was the most effective treatment in this respect in vitamin C with values (10.88 & 10.69 %) respectively compared with the combination of boron and zinc at 3 g/L treatment.

The combination of boron and zinc at 1g/L and nitrogen application time treatment (N_2) as (N_2+B_1+Zn_1) increased vitamin C content of the fruit (mg/100g) in both seasons (11.63 & 11.13), while the treatment (N_5) with boron and zinc combination in concentration 3 g/L as (N_5+B_3+Zn_3) showed the lower values in both seasons with (9.33 and 8.56), respectively. Singh and Brahmchari [33] reported that B and Zn sprays enhanced ascorbic acid content in guava.

4. CONCLUSION

In conclusion the present study clearly illustrate that nitrogen fertilization regimes clearly affect the cropping and its' attributes in avocados. Also for foliar application of boron and zinc in combination, it showed clear enhancements in terms of increasing pollen grains germination percentage leading to result in higher yield potential beside improve quality parameters of the avocado.

5. RECOMMENDATION

As a recommendation it is preferable to fertilize avocado trees cv. Feurte with nitrogen at 240 g / tree during (January), 600 g/ tree during (May) and 360 g/tree during (August) combined with 3 foliar application of boron and zinc at 1g/L at for three times, the first at the beginning of flower bud induction in (October), the second spray at bud burst during (January) and the last and third one was at anthesis in (April).

ACKNOWLEDGEMENTS

The authors appreciate Faculty of Agriculture - Cairo University and The efforts of Horticulture Research Institute for provision of research stations and laboratories that were suitable to accomplish this work. The Department of Tropical Research to provide help to ensure the manuscript for this paper was prepared and processed is highly appreciated.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://prh.sdiarticle3.com/review-history/26757