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Influence of Girdling and N Application Time on Fruiting and Fruit Quality of Avocado "Fuerte" Cultivar

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Abstract: A field experiment was conducted to study the performance of avocado trees under different nitrogen application time treatments and two girdling levels during 2015 and 2016 seasons on 20-year-old avocado trees (*Persea Americana* Mill.) "Fuerte" cultivar grafted on Dayouk rootstock. Five treatments of nitrogen additions as (N_0, N_1, N_2, N_3 and N_4) rated 1200 g /tree in 3 times as NH_4No_3 (33. 5%) all only once and combined with three levels of girdling as (G_0, G_1 and G_2) rates were laid out in randomized complete block design with three replications. The results showed that using different N applications time and levels of girdling had significant effect on fruit set, yield, fruit quality (fruit weight, flesh weight, oil content and total fruit protein) in both seasons of study. On the other hand, all the previous parameters were significantly affected by the interactions of nitrogen fertilizers and girdling treatments and improved most of the tested parameters. The study revealed that, nitrogen soil application time (N_1) with girdling treatment for only one time (G_1) was more effective than the other treatments and gave significantly the highest values compared with the other tested treatments in both seasons of study.

Key words: Nitrogen application time · Girdling · Avocado · Fruit set · Yield · Oil and Protein content

INTRODUCTION

The avocado (*Persea Americana*, Mill.) belongs to the family Lauraceae. It has developed into three horticultural races (West Indian, Guatemalan and Mexican which are adaptable to a wide range of soil and climatic conditions [1]. Avocado is an important subtropical fruit with high market value in local markets or to export. Fuerte is a hybrid of the Mexican and Guatemalan types confirmed by Schnell *et al*. [2]. The maternal parent tree was believed to be Mexican. Fuerte is cool temperature tolerant, has thin skin and anise scented leaves (when crushed), all Mexican characteristics. The superior flesh quality is regarded as characteristic of Guatemalan avocados. Fuerte is a very high eating quality winter and spring fruit and flowers prodigiously from May to November (generally). It is a 'B' flower type; early set fruit are much superior to Hass.

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 [3]. In addition, nitrogen deficient trees were found to be more susceptible to frost damage [4]. In many growing areas, avocado growers tend to apply large amounts of nitrogen to their plantations. The chief pollutant at the present is nitrate which is applied routinely in quantities much greater than those actually required for the growth of the avocado. The best way to overcome this problem is probably to calibrate fertilizer applications to the nutrient demand and seasonal growth patterns in the avocado as suggested by Whiley *et al.* [5]. However, very little data and experimental results exists in this direction.

Girdling is a management tool which is applied in order to direct nutrients to, or concentration nutrients at the site of greatest need to affect a particular plant process. As with any other manipulation process, girdling can however affect the tree physiology and phenology for a certain length of time after its application. Girdling has been practiced to increase productivity in many fruit trees. The removal of the bark prevents carbohydrates from going down the tree to the roots. These carbohydrates are then used by the upper portion of the tree to increase fruit set.

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The study aimed to evaluate girdling treatment with different nitrogen application time on fruiting and fruit quality of "Fuerte" avocado under Egypt conditions.

MATERIALS AND METHODES

The present investigation was carried out during two successive seasons of 2015 and 2016 on mature healthy avocado trees (Persea Americana Mill.) Fuerte cv. Grown at the Experimental orchard of the Horticulture Research Station at El-Qanater El-Khayria, El-Qalubia Governorate, Egypt, to study the influence of nitrogen application time and girdling treatments on productivity and fruit quality parameters of avocado trees "Fuerte" cv. The experimental trees grown in loamy clay soil, planted at 7x7 meters , irrigated with a farrow (surface) irrigation system, grafted on Dayouk rootstock , nearly uniform in vigor and received the same cultural practices and received the following treatments in both seasons of study.

Nitrogen Application Time Additions: Several five additions as 1200 gm N were considered based on percentage and time of application as follow:

N_0: Control as farm's fertilization system. 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_1: 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_2: 600 g/tree (50%) in (January), 360 g/tree (30%) in (May) and 240 g/tree (20%) in (August).
N_3: 600 g/tree (50%) in (January) and 600 g/tree (50%) in (May).
N_4: 600 g/tree (50%) in (May) and 600 g/ tree (50%) in (August).

Girdling Treatments: Girdling for the selected trees by removing the bark in diameter 1/2 cm about 5cm above the abscission zone in width circular pattern around the limbs with a sharp knife without the removal of any tissue.

G_0: Control without girdling.
G_1: One time only at mid-May.
G_2: Twice in mid-October and mid-May.

The combination between the two factors of study on treated trees as follows: N_0+G_0, N_0+G_1, N_0+G_2, N_1+G_0, N_1+G_1, N_1+G_2, N_2+G_0, N_2+G_1, N_2+G_2, N_3+G_0, N_3+G_1, N_3+G_2, N_4+G_0, N_4+G_1 and N_4+G_2.

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

Fruit Set (%): In both seasons, fruit set was determined by marking five flowering branches around the circumference of each treated trees two weeks after full bloom and fruit set percentage was calculated. On the last week of August just at harvest time the number of fruit/ branch was counted to estimate the final fruit set.

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

Yield (Kg / Treatment): After harvesting, fruits of each treatment were counted and weighed in Kg and the yield was determined as:

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

Fruit Quality Parameters: A random sample of five mature fruits from each considered tree was collected, cleaned and putted in carton boxes in one layer and transferred to laboratory for assessing the effect of considered treatments on quality parameters.

Physical Parameters: The following parameters were determined: fruit weight (g) and flesh weight (g) by using a digital balance.

Chemical Parameters: Oil content percentage 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 according to Garces and Mancha [6]. Total fruit protein were measured from nitrogen in fruits X 6.25 with (gm / 100gm) according to A.O.A.C. [7].

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 [8]. Attained means were compared by using New LSD method at 5% according to Mead *et al.* [9].

RESULTS AND DISCUSSION

Fruit Set Parameters: Data on fruit set parameters is presented in Table (1) and (2). Firstly, fruit set percentage was significantly the highest in nitrogen soil application time treatments with (N_1) (54.13 & 54.70 %) while (N_4) and (N_0) showed the lowest values with (52.28 & 52.30 %) in the 1st season and with (51.76 & 51.69 %) in the 2nd season. Results of girdling treatments showed the highest percentage (54.14 & 54.16 %) with (G_1) with significant different with (G_0) and (G_2) in the two seasons which obtained the lowest fruit set. Interactions results reveal that highest fruit set (55.26 & 56.19 %) were due to (N_1+G_1). Hodgson and Cameron [10], Homsky [11], Malo [12] and Ulman and Ben-Ya'acov [13] reported that in avocado an increase in fruit set resulting from girdling branches. Also, Lahav *et al.* [14] showed that Early September girdling was more effective than later or no girdling. It increased flowering intensity significantly, increased the percentage of seedlings that set from 15% to 66% and increased 7-fold the number of fruits harvested per seedling as compared with the ungirdled control. These results are in agreement with Christine [15] who proved that in avocado trees girdling was an effective method for altering resource allocation during fruit set.

The seasons of the investigation had significant effects as in table (2) on the total yield, highest treatment effect in nitrogen application time was in (N_1) treatment with (108.5 & 108.7 kg) comparing with (N_0) as a control which recorded the lowest values (96.4 & 95.6 kg). On average bases, highest yield in girdling treatments were on trees treated with (G_1) (115.7 & 115.8 kg), on the opposite (G_0) with (94.5 & 94.2 kg) and (G_2) with (98.7 & 96.4 kg) were significantly different which showed the lowest yield in both seasons. As for the interaction effect, the treatment (G_1+N_1) in both seasons resulted in the highest yield (117.3 & 119.1 kg). All the rest treatments except (G_0+N_0) treatment attained comparable results. Trochoulias and O'Neill [16] found that girdled limbs of 'Fuerte' avocado produced a bigger crop than controls for 3 consecutive years. Besides, Citeseer and Köhne [17] revealed that in avocado trees girdling of all main limbs in four-year-old Hass trees in the year prior to tree thinning, increased individual tree yields by 60%. Also, Lahav *et al.* [18] resulted that Girdled branches of 6 avocado cultivars usually bore an increased subsequent crop. Besides, Smith [19] found that T4 timing of N application (one-quarter in each of February, April, August and October) on mango trees giving the highest yield.

Fruit Quality Parameters: Data in Tables (3), (4), (5) and (6) show the effect of conducted treatments on fruit quality. Fruit weight in nitrogen application time treatments was significantly the highest in (N_1) with (293.1 & 299.4 g) compared with addition in (N_4) with (250.5 & 242.1 g). For girdling treatments heaviest fruits were born in trees that were treated single girdling treatment (G_1) (281.8 & 294.1 kg) compared with (G_2) in both seasons. Interaction results show that heaviest fruits were born on trees that were treated by (G_1+ N_1) with (336.3 & 367.4 g) compared with those a double girdling treatment combined with all nitrogen application time treatments. Lahav *et al.* [20] showed a highly significant decrease in fruit weight of the 'Ettinger' cultivar due to girdling and similar findings were obtained with the 'Fuerte' cultivar. Girdled 'Nabal' branches produced twice as much fruit as the un-girdled control. Both branches were not particularly heavy laden. In consequence, the average fruit weight was the same. This results in line also with Villiers *et al.* [21] on peach trees reported that the effects of girdling on fruit growth stages II and III and on post-harvest quality were studied. Trees were girdled at the beginning of growth stage II. The consequent increase in fruit size was due to a 29% increased growth rate during growth stage II. Zhao *et al.* [22] found that the combination of girdling and urea application increased fruit size and weight, VCC and TAAC. Also, Nevin *et al* [23] reported that urea leaf sprays on mature 'Fuerte' avocado trees in the field up to three sprays a year were applied , urea sprays resulted in an increase in 'Fuerte' fruit yield, size and weight (no leaf analysis reported).

Flesh weight was significantly affected by the treatments. On the average of nitrogen application time treatments, (N_1) addition resulted in the heaviest flesh weight (250.2 & 260.3 g) compared with (N_0) and (N_4) treatments. For girdling treatments, highest flesh weight (230.2 & 245.3 g) resulted with single girdling (G_1) compared with the lowest values from (G_2) with (205.7 & 208.7 g). As for the interaction effect, heaviest flesh was from fruits born on (G_1+N_1) trees (283.6 & 304.1 g) for both considered seasons respectively. Comparable results were attained by the treatment (G_2) with all tested nitrogen additions in the two seasons. Steven [24] revealed that effect was increased on fruit retention, fruit size, tree yield and fruit quality of applications of KNO3 to trees of the former for some mango cultivars.

As for the oil content percentage in Table (5), it was significantly higher in factor of nitrogen additions in (N_1) treatment with (15.19 & 15.49 %) compared to (N_4) with (14.02 & 13.91 %). On the girdling treatments average,

Table 1: Effect of girdling and nitrogen soil application time treatments on fruit set percentage per tree during seasons 2015and 2016

Fruit set (%)						
	1st season					
Treatment	N_0	N_1	N_2	N_3	N_4	Mean (B)
G_0	51.13	53.67	52.63	52.60	51.17	52.11
G_1	53.36	55.26	54.30	54.13	53.66	54.14
G_2	52.43	53.46	53.16	52.46	52.03	52.71
Mean (A)	52.30	54.13	53.36	53.06	52.28	
	2nd season					Mean (B)
G_0	50.13	55.70	53.57	52.50	51.57	52.69
G_1	54.78	56.19	54.00	53.52	52.40	54.16
G_2	50.17	52.23	52.13	51.43	51.33	51.46
Mean (A)	51.69	54.70	53.22	52.48	51.76	
New LSD at 5%	1st season (A) = 0.115 (B) = 0.126 (AB) = 0.282					
	2nd season (A) = 0.142 (B) = 0.158 (AB) =0.290					

Table 2: Effect of girdling and nitrogen soil application time treatments on yield during seasons 2015and 2016.

Yield (Kg)						
	1st season					
Treatment	N_0	N_1	N_2	N_3	N_4	Mean (B)
G_0	73.4	104.8	101.0	99.3	93.8	94.5
G_1	115.4	117.3	116.1	116.2	113..6	115.7
G_2	100.6	103.4	100.5	97.5	91.3	98.7
Mean (A)	96.4	108.5	105.9	104.3	99.5	
	2nd season					Mean (B)
G_0	76.1	105.9	102.7	97.5	89.0	94.2
G_1	116.5	119.1	116.5	115.3	111.7	115.8
G_2	94.4	101.2	100.7	95.2	90.4	96.4
Mean (A)	95.6	108.7	106.6	102.6	97.0	
New LSD at 5%	1st season (A) = 1.542 (B) = 1.312 (AB) = 2.060					
	2nd season (A) = 1.831 (B) = 1.460 (AB) =2.215					

Table 3: Effect of girdling and nitrogen soil application time treatments on fruit weight during seasons 2015and 2016.

Fruit weight (g)						
	1st season					
Treatment	N_0	N_1	N_2	N_3	N_4	Mean (B)
G_0	258.0	298.7	265.0	262.4	263.2	269.5
G_1	263.5	336.3	273.5	269.4	266.1	281.8
G_2	231.7	244.4	233.4	222.4	222.1	230.8
Mean (A)	251.1	293.1	257.3	251.4	250.5	
	2nd season					Mean (B)
G_0	266.1	307.3	271.7	269.2	255.4	273.9
G_1	285.4	367.4	281.2	272.3	264.4	294.1
G_2	209.6	223.5	220.3	211.3	206.5	214.2
Mean (A)	253.7	299.4	257.7	250.9	242.1	
New LSD at 5%	1st season (A) = 1.013 (B) = 3.872 (AB) = 1.142					
	2nd season (A) = 1.207 (B) = 4.235 (AB) = 1.206					

Table 4: Effect of girdling and nitrogen soil application time treatments on flesh weight during seasons 2015 and 2016.

Flesh weight (g)						
	1st season					
Treatment	N_0	N_1	N_2	N_3	N_4	Mean (B)
G_0	203.1	251.8	213.9	211.0	205.8	217.1
G_1	210.5	283.6	224.2	219.1	214.0	230.2
G_2	202.2	215.2	210.4	200.7	200.9	205.7
Mean (A)	205.2	250.2	216.1	210.2	206.7	
	2nd season					Mean (B)
G_0	203.0	257.2	220.0	213.9	209.7	220.7
G_1	233.0	304.1	237.5	231.6	219.5	245.1
G_2	205.3	219.6	218.7	200.0	200.3	208.7
Mean (A)	213.7	260.3	225.4	215.1	209.8	
New LSD at 5%	1st season (A) = 1.225 (B) = 3.614 (AB) = 2.580					
	2nd season (A) = 1.473 (B) = 3.902 (AB) = 2.776					

Table 5: Effect of girdling and nitrogen soil application time treatments on oil content during seasons 2015and 2016

Oil content (%)						
	1st season					
Treatment	N_0	N_1	N_2	N_3	N_4	Mean (B)
G_0	14.44	15.27	15.20	15.17	14.72	14.96
G_1	14.58	15.81	15.41	15.23	14.60	15.13
G_2	14.47	14.50	14.43	14.15	12.75	14.06
Mean (A)	14.50	15.19	15.01	14.85	14.02	
	2nd season					Mean (B)
G_0	14.63	15.54	15.28	15.10	14.64	15.04
G_1	15.32	16.32	15.30	15.26	14.58	15.36
G_2	14.30	14.61	14.19	14.08	12.52	13.94
Mean (A)	14.75	15.49	14.92	14.81	13.91	
New LSD at 5%	1st season (A) = 0.126 (B) = 0.148 (AB) = 0.242					
	2nd season (A) = 0.114 (B) = 0.157 (AB) = 0.212					

highest percentage of oil content was due to (G_1) treatment with (15.13 & 15.36 %) with significant differences with (G_2) treatment which obtained the lowest values. As for the interaction effect the treatment of (N_1+G_1) with (15.81 & 16.32 %) recorded highest significant oil content percentage. Meanwhile, double girdling treatment resulted in the lowest oil content regardless of nitrogen treatments under investigation in both seasons. Davie *et al*. [25] indicate that girdling a number of branches on a Hass tree increased fruit size, tree performance and all fruit quality parameters.

Total protein in Table (6) was significantly higher in nitrogen treatments with (N_1) treatment with (4.61 & 4.65) compared to the treatment (N_4) followed by control (N_0) on the average. As for the girdling treatments effect, (G_1) treatment resulted in significantly the highest total protein

Table 6: Effect of girdling and nitrogen soil application time treatments on total protein during seasons 2015and 2016.

Total protein (gm / 100gm)						
	1st season					
Treatment	N_0	N_1	N_2	N_3	N_4	Mean (B)
G_0	2.21	5.06	4.81	3.22	2.51	3.56
G_1	3.54	5.28	5.31	3.35	2.67	4.03
G_2	2.13	3.50	3.24	2.38	2.19	2.69
Mean (A)	2.63	4.61	4.45	2.98	2.46	
	2nd season					Mean (B)
G_0	2.25	5.15	4.85	3.19	2.46	3.58
G_1	3.73	5.50	4.16	3.22	2.30	3.78
G_2	2.00	3.31	2.96	2.27	2.22	2.55
Mean (A)	2.66	4.65	3.99	2.89	2.33	

New LSD at 5% 1st season (A) = 0.015 (B) = 0.017 (AB) = 0.036
2nd season (A) = 0.019 (B) = 0.023 (AB) = 0.042

in fruits (4.03 & 3.78) compared to the lowest values in (G_2) with (2.69 & 2.55). As for the interaction effect, (G_1+N_1) treatment resulted in the significantly the highest total protein amounting to (5.28 & 5.50) on the opposite with (G_2) with either of nitrogen treated treatments in both seasons.

CONCLUSION

Girdling of limbs at mid-May and addition of nitrogen fertilizer in three doses 20% in January, 50% in May and 305 in August proved to be the most adapted management for productivity of "Fuerte" avocado.

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