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Effect of Nitrogen and Potassium Fertilizer on Avocado Cv. Fuerte on Yield and Economic Return

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Abstract: This study was conducted during three successive seasons from 2018 to 2020 at Horticulture Research Station at El-Kanater El-Khayria, Qalyubeia Governorate on 20-years-old avocado trees (*Persea americana* Mill.) "Fuerte" cultivar grafted on Dayouk rootstock and grown in loamy soil under surface irrigation system. Nitrogen and potassium fertilization at 200, 400 and 600g /tree as $(NH4)_2 SO_4$ 20. 5% and K_2SO_4 (50%) were applied independently or in combination three times during (January, April and May). Leaf NK content, fruit set, fruit retention as well as yield, fruit weight, oil percentage and economic return were investigated. The obtained results showed that nitrogen and potassium soil application were significantly affected on improving all the tested parameters. The study also showed that, nitrogen soil application at the rate 600g actual/tree/year with potassium 400g actual/tree/year was more effective than the other treatments and gave significantly the highest values in comparison of other testes treatments in studied seasons of study. The highest yield and fruit weight were achieved from Fuerte avocado trees fertilized with 600g actual N with 400g actual K_2O/ tree/year. Regarding, oil percentage, the differences between treatments did not reach the level of significance. The economic return gradually increased by increasing NK fertilizers. Trees were fertilized with the 600 g N + 400 g K_2O/ tree /year gave the highest income compared with other treatments. While the lowest rate of NK fertilizer (200 g N+ 600 g K_2O/tree /year) gave the lowest income.

Key words: Avocado · NK nutrient · Yield · Oil content

INTRODUCTION

The avocado fruit is a highly nutritious fruit with many studies confirming its positive effects on human health [1, 2]. Fertilization is one of the most important factors which limiting growth and productivity in avocado like all economical plant species. An understand of seasonal nutrient requirements of crops is important in order to develop best fertilizer managements practices. Hass avocado trees absorb nutrients according to seasonal growth patterns and matching fertilizer applications to those patterns and maximize yield improve fruit quality, increase nutrient uptake and reduce the potential for nutrient loss [3]. Fuerte avocado had many faults and it must replace by a smaller fruit of better quality. The need exist for awards of acceptable, commercial quality that can withstand environmental conditions in central Florida and other areas that have similar climates. Research supports the feasibility of breading cold-tolerant cultivars of high horticultural quality [4]. Management of N is complex because both avocado tree nutritional status and orchard soil fertility vary greatly among local avocado-growing areas [5, 6]. Despite problems of low yield, small fruit size and alternate bearing, 'Hass' avocado dominates the global avocado industry [7]. For every one ton per hectare of fruit yield, the normal growing conditions approximates: nitrogen 7kg, phosphorus 1.5kg, potassium 8kg, calcium 3.5kg and magnesium 1.5kg. Apply nitrogen and potassium fertilizers following the summer fruit drop through to the end of autumn and phosphorus four times per year [8]. Nitrogen acts directly on vegetative growth, emissions and the development of shoot plants and increases the amount of dry matter in plants [9]. Potassium is the macronutrient extracted in greater amounts by plants which directly affects photosynthesis, the translocation of photosynthetic and the water balance in plants and fruits [10].

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The goal of this study was to develop a best management practice for N and K fertilization and their effects on the phrenological and productive characteristics of Fuerte avocado cultivar.

MATERIALS AND METHODS

This work was done during from 2018 to 2020, seasons on avocado trees cv. Fuerte grown in Kanater (Horticulture research station) at Kalyobia Governorate. The selected trees were 20-years-old at beginning of study, planted in loam soil and irrigated with farrow system. Soil texture in this study was clay loamy textured. Mechanical and chemical analyses of the experimental soil from 0-30 cm. depth was determined according to the methods described by Wilde *et al.* [11] and data are shown in Table (1).

The chosen trees were grafted on avocado seedling rootstocks and planted at 7x7 m spaces and subjected to the normal annual agricultural practices.

Nitrogen and Potassium were applied in different rates and their combinations, Nitrogen (200, 400 and 600 g actual/tree) and potassium (200, 400 and 600 g actual K_2O/tree were added in the form of ammonium sulphate (20.5 % N) and potassium sulphate (48% K_2O) respectively. Fertilizer was split into 3 doses i.e. January, April and May according to Shamima *et al.* [12].

Measurements

Leaf Nutrient Analysis: In September of each year, 20 six-month-old spring flush leaves from non fruiting terminals shoots were collected uniformly around each tree [13]. Leaf sample was washed by tap water then with distilled water and dried using oven at 70°C to a constant weight then grounded and subjected to the following determinations: A -Total nitrogen (%) was determined by Micro-Kjeldahle method as described by Pregl [14].

B-Potassium (%) was determined by using the Atomic Absorption Spectrometer (Perkin–Elemer, Model 3300) according to the methods described by Chapman and Pratt [15].

Fruit Set %: Number of set fruits per branch was recorded one month after full bloom; 5 attached branches of each tree were used for this purpose. The percentage of fruit set was calculated using the following equation:

$$\text{Fruit set (\%)} = \frac{\text{Av. number of set fruits/branch}}{\text{Av. number of flowers/branch}} \times 100$$

Fruit Retention %: Number of retained fruits/ branch was recorded at harvesting time; 5 branch per tree were used for this purpose The percentage of fruit retention was calculated using the following equation:

$$\text{Fruit retention (\%)} = \frac{\text{Av. number of retained fruits/branch}}{\text{Av. number of set- fruits/branch}} \times 100$$

Yield (Kg /Tree): At harvest time (in September), total yield was calculated as kg/tree (Total number of fruit/tree × Average fruit weight (g)/ 1000).

Fruit Properties: Twenty seven fruits from each treatment (nine fruits per replicate) were collected at maturity stage to estimate fruit weight (g) and oil percentage were determined according 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 AOAC [16].

Net Returns: Total cost of fertilizers estimated using the following formula (according to Infana *et al.* [17]:

TC= TFC+T P C.

Net returns were estimated using the following formula:

NR= TI –TC.

Table 1: Mechanical and chemical analysis of orchard soil (0 – 30 cm, depth) during season of 2018

A-Physical analysis						
Sand (%)	Silt (%)	Clay (%)	Soil texture	F.C. (%)	W.P. (%)	A.W. (%)
17.7	29.1	51.2	Clay loamy	42.5	21.2	20.1

B-Chemical analysis										
	Available nutrients (mg/kg)									
	N	P	K	Fe	Zn	Mn	Cu	E.C. dsm^{-1}	pH (1:2.5)	$CaCo_3$
Total	677	340	452.5	315.6	113	146	47	3.71	7.8	3.6
Avail.	63	13.7	61.2	21.1	5.7	16.6	2.6			

Statistical Analysis: Data were subjected to analysis of variance for factorial plot design in randomized complete blocks [18]. Differences between treatments Means were separated by the New L.S.D [19] least significant differences test at a 0.05 probability level.

RESULTS AND DISCUSSION

Leaf Minerals Concentration: Nitrogen fertilization strategy had significant effect on leaf N concentration. Trees receiving soil-applied 600 g N/year accumulated leaf N concentrations that were significantly greater than trees receiving soil-applied200 or 400g N/year. The highest values of N concentration were showed with 600 g N/tree /year in the three studied seasons. Concerning of interaction between the rate of N and K-fertilizer, the highest value of leaf N concentration (2, 1.9, 1.9%) was detected with 600 g N/ tree /year in the three tested seasons respectively. Concerning K-concentration data tended to decrease with increasing rate of N-fertilization. K-concentration in avocado Fuerte leaves tended to increase as K-fertilization rates were increased. The greatest values of K content in the leaves were noticed with 600g K_2O/ tree /year (1.7, 1.7, 1.6%) in the three tested seasons respectively. Interaction showed significant differences between N and K fertilization rates on leaf K content. These results are in harmony with Lahav [20] who's reported that the avocado tree is known for its superficial root system, a fact to be considered in agricultural practices such as irrigation, cultivation and fertilization. Thereby, adding chemical fertilizers particularly NPK enhance chemical activities and N, P and K releasing thereby increased these elements in rooting zone, consequently increasing their absorption by the plant. By these possibilities, the concentration of NK in the root zone increased which encouraged NK absorption and consequently its accumulation in leaves [21-23]. Furthermore, Oppenhelmer [24]; Oppenheimer *et al.* [25] and Oppenheimer *et al.*[26] where noticed that the optimal level for cv. Fuerte was found to be 1.6-2.0%, below and above which there was a decrease in yield. The upper level for cv. Hass was above 2.0 % N.

Fruit Set and Fruit Retention: Fruit set % and fruit retention % of avocado cv. Fuerte were varied among the fertilization treatments. Trees were given 200g N/tree/year with 400 g K_2O/tree/year showed the highest value of fruit set (61.2, 61.6, 61.3%) and fruit retention (26.1, 25.2, 24.2) in the tested three seasons. The lowest value was observed for tree fertilized with 600g N/tree/year + 600 g K_2O/tree/year (58, 57.9, 56.3% fruit set and 18.3, 19.5, 19.5 fruit retention) respectively. This result supports the hypothesis that it is important to meet the N demand of the multiple physiological and developmental process that occur concurrently in 'Hass' avocado tree phenology during the summer, the major period of N uptake by the fruit [27]. It should also be noted that soil-applied in August produced similar yield results as in July plus August. June drop for the developing fruit occurs from mid-June through August in California [28, 7]. Summer vegetative shoot growth and exponential fruit growth occur in July through August [29]. In addition, the end of July to beginning of August is when abscission of the mature fruit begins and inflorescence initiation for next year's crop takes place [28, 7, 30].

Yield (Kg/Tree): It is obvious from data in Table 4 that in studied seasons on the average yield significantly varied in response to different rates of nitrogen and potassium soil application. The highest significant yield (29.1, 30.2 and 31.3 kg) were recorded with 600g N/tree/year, while significantly the lowest yield (22.8, 24.8 and 25.2 kg) was obtained from 200gN/tree/year. On the other hand, yield of avocado varied on the average due to potassium treatments, the highest significant yield (30.0, 29.0 and 29.8 kg) were attributed to, while significantly the lowest yield (26, 26.7 and 26.5 kg) was obtained from 600g K_2O/tree/year. Interaction between the studied factors was statistically significant which referred to that nitrogen soil application and potassium, dependently in this concern. The highest yield (31.6 31.5 and 35.1 kg) was attributed to (600g N+400g K_2O) treatment in the three seasons respectively, while the lowest yield (19.7, 22.6 and 22.8 kg) were obtained from (200g N+600g K_2O) treatment in the three seasons, respectively. These results are harmony with Sharma *et al*. [31] who reported that application of 800 g N + 200 g P + 300 g K significantly increased the yield/tree of mango.

Shamima *et al.* [12] reported that higher fertilizer levels possibly produced some barrier on nutrition of mango trees or prevalence of other constraints in soil and hence reduced the yield.

Fruit Weight (g): Data in Table (4) showed that there are significant differences in fruit weight between the tested treatments, the average values of the three seasons

Table 2: Effect of different rates of NK fertilization on leaf N content (%) and leaf K content (%) of avocado cv Fuerte during 2018, 2019 and 2020 seasons

	First season				Second season				Third season			
	K – Fertilization (g actual K_2O/tree /year)											
N – Fertilization (g actual /tree /year)	200	400	600	Mean	200	400	600	Mean	200	400	600	Mean
	Leaf N (%)											
200	1.5	1.6	1.7	1.6	1.6	1.8	1.8	1.7	1.6	1.7	1.8	1.7
400	1.7	1.85	1.9	1.8	1.65	1.9	1.85	1.8	1.7	1.8	1.9	1.8
600	2.0	2.1	2	2.0	1.8	2	2	1.9	1.8	1.9	2	1.9
Mean	1.7	1.9	1.9		1.7	1.9	1.9		1.7	1.8	1.9	
New L.S.D. at 0.05	N=0.15 K=0.19 NK=0.21				N= 0.16 K=0.18 NK=0.25				N= 0.16 K=0.19 NK=0.22			
	Leaf K (%)											
200	0.95	1.5	1.8	1.4	1	1.4	1.8	1.4	1.1	1.2	1.4	1.2
400	1.2	1.7	1.9	1.6	1.1	1.6	1.9	1.5	1.2	1.4	1.5	1.4
600	1.4	1.8	2	1.7	1.3	1.8	1.9	1.7	1.3	1.7	1.8	1.6
Mean	1.2	1.7	1.9		1.1	1.6	1.9		1.2	1.4	1.6	
New L.S.D. at 0.05	N= 0.19 K=0.21 NK=0.35				N= 0.09 K=0.11 NK=0.25				N= 0.9 K=0.21 NK=0.30			

Table 3: Effect of different rates of NK fertilization on fruit set (%) and fruit retention (%) of avocado cv Fuerte during 2018, 2019 and 2020 seasons

	First season				Second season				Third season			
	K – Fertilization (g actual K_2O/tree /year)											
N – Fertilization (g actual /tree /year)	200	400	600	Mean	200	400	600	Mean	200	400	600	Mean
	Fruit set %											
200	60.3	61.2	62.1	61.2	61.6	61.6	60.6	61.3	60.3	61.3	59.6	60.4
400	59.6	59.1	58.5	59.1	60.3	58.9	58	59.1	58.5	58.4	57.6	58.2
600	59	58.9	58	58.6	58.3	58.1	57.9	58.1	57.9	57.6	56.3	57.3
Mean	59.6	59.7	59.5		60.1	59.5	58.8		58.9	59.1	57.8	
New L.S.D. at 0.05	N=3.26 K=4.31 NK=5.21				N= 3.86 K=4.56 NK=5.8				N= 3.56 K=4.6 NK=6.3			
	Fruit retention %											
200	26	26.1	24.3	25.5	23.5	25.2	22.3	23.7	23.1	24.2	22.1	23.1
400	23.7	22.2	20.1	22.0	22.1	21.1	20.1	21.1	21.1	20.1	19.5	20.2
600	20.7	19.5	18.3	19.5	21.1	20.1	19.5	20.2	20.2	19.5	19	19.6
Mean	23.5	22.6	20.9		22.2	21.3	20.6		21.5	21.3	20.2	
New L.S.D. at 0.05	N= 2.57 K=3.1 NK=4.25				N= 2.1 K=3.2 NK=4.2				N=2.5 K=3.1 NK=3.9			

Table 4: Effect of different rates of NK fertilization on yield/ tree (kg) and fruit weight (g) of avocado cv Fuerte during 2018, 2019 and 2020 seasons

	First season				Second season				Third season			
	K – Fertilization (g actual K_2O/tree /year)											
N – Fertilization (g actual /tree /year)	200	400	600	Mean	200	400	600	Mean	200	400	600	Mean
	Yield/ tree (kg)											
200	21.8	26.8	19.7	22.8	26.6	25.2	22.68	24.8	25.6	27.1	22.8	25.2
400	24.5	31.5	29.2	28.4	28.2	30.3	27.8	28.8	28.5	27.2	25.3	27.0
600	26.6	31.6	29.2	29.1	29.5	31.5	29.5	30.2	31.5	35.1	31.3	32.6
Mean	24.3	30.0	26.0		28.1	29	26.7		28.5	29.8	26.5	
New L.S.D. at 0.05	N=2.1 K=3.2 NK=3.9				N= 2.4 K=3.6 NK=4.1				N= 2.3 K=3.8 NK=4.1			
	Fruit weight (g)											
200	270	260	260	263.3	280	280	280	280.0	290	280	290	286.7
400	280	270	272	274.0	290	290	290	290.0	300	300	301	300.3
600	295	309	290	298.0	303	310	300	304.3	300	310	300	303.3
Mean	281.7	279.7	274.0		291.0	293.3	290.0		296.7	296.7	297.3	
New L.S.D. at 0.05	N= 9.2 K=10.2 NK=10.5				N=9.5 K=10.2 NK=10.5				N=9.5 K=10.3 NK=10.9			

Table 5: Effect of different rates of NK fertilization on Oil (%) of avocado cv Fuerte during 2018, 2019 and 2020 seasons

	Oil (%)											
	First season				Second season				Third season			
N – Fertilization (g actual /tree /year)	K – Fertilization (g actual K_2O/tree /year)											
	200	400	600	Mean	200	400	600	Mean	200	400	600	Mean
200	17.2	16.5	16.6	16.8	17.5	17.2	17	17.2	16.9	16.2	16.1	16.4
400	16.5	15.5	15.5	15.8	17.2	17	16.8	17.0	16.4	16.3	16.2	16.3
600	16.1	15	15.1	15.4	16.9	16.8	16.5	16.7	16	16	16	16.0
Mean	16.6	15.7	15.7		17.2	17.0	16.8		16.4	16.2	16.1	
New L.S.D. at 0.05	N= 0.56 K=0.66 NK=0.98				N= 0.59 K=0.75 NK=1.0				N= 0.59 K=0.77 NK=1.1			

Table 6: Effect of N and K fertilization on net-return of avocado cv Fuerte

Treatment (g) Actual/tree/year	Cost of fertilizers (pound)/ fed. NK (kg)	Others	Cost of pesticides (pound)/fed.	Total	Yield /fed. price (pound)	Net – income (pound)/ fed.
200N+200K2O	574	600	500	1674	35752	30246
200N+400 K2O	905	600	500	2005	43952	28235
200N+600K 2O	1230	600	500	2330	32308	24880
400N+200K2O	820	600	500	1920	40180	31920
400N+400K2O	1148	600	500	2248	51660	34112
400N+600K2O	1476	600	500	2576	47888	30784
600N+200K2O	1066	600	500	2166	43624	33234
600N+400K2O	1394	600	500	2494	51824	35306
600N+600K2O	1722	600	500	2822	47888	32578

showed that fruits which treated with 600 g N+400g K_2O/tree /year were superior among the tested trees in weight comparison with the other treatments. The maximum fruit weight was produced by 600 g N+400g K_2O/tree /year treatment perhaps supply of sufficient amount of nutrients necessary for better growth and plant development. It indicated that higher fertilizer levels possibly produced some barrier on nutrition of mango or prevalence of other constraints in soil and hence reduced the yield. Plants grown without (native nutrient) added or lower fertilizer produced the lowest yield/tree irrespective of years [12].

Oil %: The average of the three years showed insignificant differences in fruit oil percentage between the all treatments. In general oil percentage was the lowest in fruits which treated with 600N+400 K_2O g/tree/year (15, 16.5 and 16 %) and the highest in 200N + 200K_2Og /tree/year (17.2, 17.5 and 16.9%) respectively. These results are in agreement with those of [32] who illustrated that there was no significant different were observed in fat percentage, however this result in the line and agree with AbouAziz *et al.* [33] and Desouky *et al.* [34].

The Economic Return: The economic return of Fuerte avocado tree (Table 6) showed that net income gradually increased by increasing NK fertilizers. Trees were fertilized with 600g N + 400g K_2O/tree /year gave the highest income (35306 L.E./fed/year) followed by 400g N + 400g K_2O/ tree /year (34112 L.E./fed/year) compared with other treatments. While the lowest rate of NK fertilizer (200gN + 600 g. K_2O tree /year) gave the lowest income (24880 L.E./fed./year).

CONCLUSION

From the above mentioned results, it could be concluded that, fertilized avocado trees with (600g N and 400g K_2O) /tree/year were the most effective treatment in increasing leaf nutrient contents, yield, fruit weight, oil content as well as economic return of "Fuerte" avocado trees.

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