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Response of Two-Year-Old Trees of Four Olive Cultivars to Fertilization

Nawaf M. Freihat and Yara K. Masa'deh

Department of Plant Production, Faculty of Agriculture,
Jordan University of Science and Technology, P.O. Box 3030, Irbid 22110, Jordan

Abstract: Two-year-old rooted cuttings of four olive cultivars (Nabali, Grossa d' España, Nabali Mohassan and Manzanillo) were grown in pots to study their response to different concentrations (0, 16, 32 and 48 g/tree) of two types of fertilizers (20:20:20 NPK and 20 N-ammonium sulfate) under greenhouse and field conditions. Results of greenhouse experiment indicated that different fertilizer treatments increased leaf nitrogen content, shoot length and shoot dry weight, but negatively affected phosphorus content and root dry weight and had no effect on potassium content. However, "Nabali" had the highest leaf NPK content. "Grossa d' España" had the shortest shoot length, while "Manzanillo" had the highest shoot length, dry weight and root dry weight. Results of field experiment indicated that different fertilizer treatments had no effect on leaf nitrogen content and adversely affected phosphorus leaf content, they also negatively affected potassium content but not the 48 g NPK/tree and 16 g N/tree, however, they improved shoot length and shoot dry weight but did not affect root dry weight except 32 g N/tree treatment. "Nabali Mohassan" and "Manzanillo" had the longest shoot.

Key words: Olives · *Olea europaea* L.

INTRODUCTION

Olive's nutrient requirements are lower than that for many other fruit trees, but shortage in these requirements costs the tree major physiological disorders [1, 2]. Nitrogen is one of the essential nutrients needed by plants mainly for chlorophyll buildup and associated with high photosynthetic activity [3, 4]. However, nitrogen uptake and metabolism is a key factor for olive roots to change the pH of their surrounding solution, which facilitates nutrients uptake by increasing their availability to the plant [5]. Phosphorus also is an important structural component essential for energy storage and transfer (ADP and ATP) for subsequent use in growth and reproductive processes [6]. In fact, almost every metabolic reaction of any significance in plant proceeds via phosphate derivatives [7]. Adequate supply of phosphorus at early growth stages is important for root growth, development of reproductive parts, disease and drought stress resistance [4, 7]. Potassium has important role in increasing water uptake and consequently in cell expansion [3]. Potassium was reported to affect transpiration rate by regulating stomata opening and closure, where high transpiration rate increases nutrients absorption [7, 8]. However, low potassium reduce nitrogen uptake [1]. Olives leaf mineral composition varied among cultivars [1].

Growth of young olive trees improved with NPK fertilization [4] but most of the researches and studies concern olive tree emphasis on improving yields rather than the growth rate of young olive trees. Generally, there is lack of information about the potential of various olive cultivars and their responses to fertilization. Therefore, the objective of this study was to investigate the effect of four levels of two fertilizer types (20-20-20 NPK and 20 N) on growth and development of two-year-old rooted cuttings of four olive cultivars (Nabali, Grossa d' España, Nabali Mohassan and Manzanillo) under greenhouse and field conditions.

MATERIALS AND METHODS

Two pot experiments were conducted at Jordan University of Science and Technology Campus under greenhouse and field conditions. Two-year-old rooted cuttings of four olive cultivars ("Nabali", "Nabali Mohassan", "Grossa d' España" and "Manzanillo") were used. Experiment was arranged in split plot design with three replicates, (cultivar is the main plot and fertilizer is the subplot). In 15 Feb. 2002 each rooted cutting was

Corresponding Author: Nawaf M. Freihat, Department of Plant Production, Faculty of Agriculture, Jordan University of Science and Technology, P. O. Box 3030, Irbid 22110, Jordan

Table 1: Treatments, Fertilizer concentration and Total fertilizer added during the experiment season

Treatments	Fertilizer concentration (g L^{-1})	Total fertilizer added (g/tree)
Control	0	0
(20:20:20) NPK	1	16
(20:20:20) NPK	2	32
(20:20:20) NPK	3	48
(20) N	1	16
(20) N	2	32
(20) N	3	48

Table 2: Initial NPK contents for olive cultivars(mg g^{-1})

	Cultivars			
Treatments	Nabali	Grossa d' España	Nabali Mohassan	Manzanillo
Nitrogen (N)	21.4	20.7	20.8	20.8
Phosphorus (P)	1.9	1.3	0.9	1.0
Potassium (K)	10.5	7.7	7.7	8.0

Table 3: Effects of cultivars and fertilizers on olives leaf nitrogen, phosphorus and potassium content under greenhouse conditions

		Leaf (mg g^{-1})		
Treatments		K	P	N
Nabali	Cultivar	10.32a	1.36a	28.29a*
Grossa d' España		9.82ab	1.09b	27.31ab
Nabali Mohassan		8.37c	1.08b	26.48bc
Manzanillo		9.31bc	1.13b	25.28c
Cultivar		NS	*	NS
Control	Fertilizer	9.23ab	1.43a	25.51b
16 NPK		9.28ab	1.28ab	26.74ab
32 NPK		9.89a	1.15bc	26.77a
48 NPK		9.71ab	1.13bc	27.79a
16 N		9.88a	1.24ab	27.02a
32 N		8.55b	0.98c	27.37a
48 N		9.31ab	0.94c	26.67ab
P-value Fetrilizer		NS	*	*
Cultivar x Fertilizer		NS	NS	NS

* Means followed by same letter (s) for each column are not significantly different (p=0.5)

transplanted into 9 L plastic pot in a mixture of 1:1:1 soil, sand and peat moss. The soil used in the experiment had the following characteristics, (pH 7.89, Ec dS m^{-1} 0.75, N-N_4 3.50 ppm, N-NO_3 9.51 ppm, P 2.27 ppm, K 543.07 ppm, $CaCO_3$15.1% and organic matter 0.52%. Fertilizer treatments started at 17 Feb. 2002 (Table 1). Treatments were applied eight times with three weeks interval. Each level of fertilizer was dissolved in two liters of tap water and added to all plants except the control plants that received tap water only. Plants were irrigated with two liters of tap water ten days after each treatment.

Leaves were collected at 16 Feb. and 6 Nov. 2002 from the median part of shoots. They were washed with distilled water, dried at 75°C till constant weight and ground to pass 30 mesh screens. 0.5 g weighed from each grounded dry leaves and analyzed to obtain nitrogen content by Kjeldhal method using Kjeltec System 1060 Distilling Unit. For phosphorus content determination 0.5 g of each grounded samples were weighed in crucibles and burned to ash in the Muffle furnace overnight at 550°C, then the ash dissolved with 5 mL 2N HCl and the extraction analyzed by the yellow color method 470 nm using the JENWAY 6105 U.V/Vis Spectrophotometer. For potassium content determination, the same performances of phosphorus analysis were followed, but the samples were examined using the Flame Photometer (JENWAY PFP7).

Shoot length for all rotted cuttings was recorded at 15 Feb. and 28 July. 2002. Shoots of all plants were separated from their roots by Nov. 6, 2002 and they were washed and then dried at 75°C in Carbolite oven for dry weight measurements.

Initial NPK contents of the rooted cuttings of four olive cultivars are shown in Table 2. Data from both experiments were the mean of three replicates of split plot design, subjected to analysis of variance and means were compared using the Least Significance Difference (LSD) method at p=0.05, using MSTAT (Michigan State University, East Lansing, MI) to evaluate the differences between fertilizers, cultivars, under greenhouse and field conditions and possible interactions.

RESULTS AND DISCUSSION

Greenhouse experiment:

Cultivar effect: All cultivars showed high nitrogen concentrations at the end of the experiment (Table 3). Different cultivars had variable responses to fertilization treatments. Irrespective of fertilizer treatments, "Nabali" had significantly the highest NPK contents compare to "Nabali Mohassan" and "Manzanillo" (Table 3). This result is very expected because "Nabali" is known to be slow growing cultivar compare to other olive cultivars especially "Nabali Mohassan" and this can explain how "Nabali" had the least shoot and root dry weight in comparison with other cultivar particularly "Manzanillo" and "Nabali Mohassan" (Table 4). However, "Nabali" and "Grossa d' España" were on the same level of significant except for phosphorus (Table 3), in accord with Jordão *et al.* [9], who reported that p-active transport varies between species and cultivars and genetically fixed as

Table 4: Effects of cultivars and fertilizers on olives shoot length, shoot dry weight, and root dry weight under greenhouse conditions

Treatments		Root dry wt. (g)	Shoot dry wt. (g)	Shoot length (m)
Nabali	Cultivars	52.79b	53.74c	2.72a*
Grossa d' España		59.14b	55.45bc	2.23b
Nabali Mohassan		56.15b	57.35ab	2.94a
Manzanillo		72.77a	60.64a	3.18a
P-value Cultivar		*	*	*
Control	Fertilizer	74.84a	44.73d	2.16c
16 NPK		61.37bc	68.25a	3.38a
32 NPK		56.95c	60.28b	2.98ab
48 NPK		45.85d	53.75c	2.17c
16 N		68.41ab	60.41b	3.26a
32 N		58.55bc	56.98bc	2.96ab
48 N		55.51cd	53.19c	2.47bc
P-value Fetrilizer		*	*	*
Cultivar x Fertilizer		NS	NS	NS

* Means followed by same letter (s) for each column are not significantly different (p=0.05)

mentioned by Mengel and Kirkby [6]. The differential accumulation of NPK in the leaves of olive cultivars indicates differential efficiency either in absorption or utilization of nutrients, which is in agreement with Bouranis *et al.* [4] and Dimassi *et al.* [1] results. This may be ascribed to differences in genotype characteristics for root growth rate, nutrient absorption efficiency and/or photosynthetic efficiency. “Manzanillo” had the highest increments in shoot length 3.18 m (Table 4), whereas “Grossa d’ España” had the least increase in shoot length (2.23 m) and was significantly lower than all cultivars, in accord with results obtained by Eryüce and Püskülcü [10]; and Jordão *et al.* [9]. Differences in shoot and root dry weight seems to be cultivar dependents, where "Manzanillo had the highest value compare to other cultivars.

Fertilizers effect: All treatments had significant increase in leaf N content over the control, except for those receiving 16 g NPK and 48 g N, respectively (Table 3). However, the control trees had the least leaf nitrogen content and no significant differences were obtained among the treated trees. In general, all treatments resulted in high nitrogen content, which could be due to the age of treated plants (two-year-old) that agrees with Ferreira [11], who reported that young plants have higher nitrogen content than the older one. Another factor might be involved is the sampling date as reported by Drossopoulos and Niavis [12], who found that leaf sampling date significantly affect olive leaves nitrogen reserves, as during winter and autumn where the vegetative growth of olive trees is at the minimum that significantly increase leaf nitrogen content, while during spring and summer the contrary happens.

Phosphorus content of the control plants was higher than any of the treated ones 1.43 mg g^{-1} (Table 3). However, trees received 48g N/tree had the lowest leaf phosphorus content 0.94 mg g^{-1}, which might be attributed to high $CaCO_3$ concentration in the soil that affect phosphorus availability to plant, in agreements with Taimeh and Hattar [13] results; or due to the diffusion of phosphorus to the root surface that can limit its uptake and this limitation may be greater for new roots that rapidly deplete phosphorus in the rhizosphere of soil solution.

None of the fertilizer treatments had a significant increased in leaf potassium content over the control (Table 3), this is in accordance with Ferreira [11], who reported that potassium do accumulates in the leaves, stems and roots at the beginning of the vegetative growth, since it is not heavily in demand at this period and may also be partially related to the addition of potassium since high potassium concentration in the soil would inhibit K-active transport mechanism, or may be due to the dilution effect of nitrogen as reported by Jordão *et al.* [14]. These results also could be related either to the mobility of potassium in soil since the plants were irrigated once every 10 days which agrees with Troncoso *et al.* [15] on "Manzanillo" olives, or due to the Ca concentration of the soil as mentioned by Dimassi *et al.* [1], since cations compete K^+ absorption by plant and lower its uptake and content in plant tissues.

It is obvious that the fertilizer treatments have significant effects on shoot length and shoot dry weight (Table 4). Trees receiving 16 g NPK and N gave significant increase in shoot length and shoot dry weight over the control; shoot dry weight followed the same trend. NPK levels had been reported to have significant influence on various parameters of olive trees particularly shoot growth [16].

The 16 g NPK had significant effect on shoot dry weight 68.25 g, compare to control and the rest of the treatments (Table 4), this could be referred to the high nitrogen concentration and other nutrients resulting in high dry matter accumulation in accordance with Fernández-Escobar and Marin [17].

On the other hand, root dry weight of control plants had the highest value 74.84 g (Table 4), whereas treated plants with NPK and N alone tended to have lower root dry weight, which does not agree with results obtained by Neilsen and Lynch [18] on *Pinus radiata*. However, trees received 48 g NPK tended to have the least root dry

Table 5: Effects of cultivars and fertilizers on olives leaf nitrogen, phosphorus and potassium content under field conditions

		Leaf (mg g^{-1})		
Treatments		K	P	N
Nabali	Cultivar	9.34a	0.87a	27.74a*
Grossa d' España		8.34b	0.87a	27.98a
Nabali Mohassan		7.87b	0.91a	28.13a
Manzanillo		7.95b	0.91a	27.70a
P-value Cultivar		*	*	NS
Control	Fertilizer	9.29a	1.36a	27.35ab
16 NPK		8.35bc	0.94b	28.63a
32 NPK		8.00cd	0.77c	28.11a
48 NPK		9.39a	0.71c	28.83a
16 N		9.10ab	0.97b	26.43b
32 N		7.30d	0.74c	28.28a
48 N		7.23d	0.76c	27.60ab
P-value Fetrilizer		*	*	NS
Cultivar x Fertilizer		NS	NS	NS

* Means followed by same letter (s) for each column are not significantly different (p=0.05)

Table 6: Effects of cultivars and fertilizers on olives shoot length, shoot dry weight, and root dry weight under field conditions

Treatments		Root dry wt. (g)	Shoot dry wt. (g)	Shoot length (m)
Nabali	Cultivars	32.14c	38.13b	1.36b*
Grossa d' España		42.98b	44.63a	1.41b
Nabali Mohassan		42.16b	42.00a	1.96a
Manzanillo		57.53a	44.23a	2.02a
P-value Cultivar		NS	*	*
Control	Fertilizer	42.50bc	34.99d	1.42c
16 NPK		46.79ab	46.95a	1.92a
32 NPK		40.76bc	42.90b	1.92a
48 NPK		44.59ac	38.66c	1.41c
16 N		36.60c	41.23bc	1.82ab
32 N		52.37a	48.94a	1.78ab
48 N		42.32bc	42.07bc	1.56bc
P-value Fetrilizer		*	*	*
Cultivar x Fertilizer		NS	NS	NS

* Means followed by same letter (s) for each column are not significantly different (p=0.05)

weight 45.85 g, which could be referred to high nutrients concentration near the photosphere that does not force roots to grow seeking nutrients, which best explain the significant increase in root dry weight of the control plants, with exception of those receiving 16 g N alone. This is in accord with Ferreira [11], who reported that low nitrogen concentration results in low shoot: root ratio.

Field experiment:

Cultivar effect: Irrespective of fertilizer treatments, all cultivars were on the same level of significant for N and P, while K was significantly higher in "Nabali" compare to other cultivars (Table 5). In addition to the environmental conditions, the genetic integrity of the plant species might influence particular nutrient uptake efficiency [2]. Moreover, this might indicate the performance efficiency of nutrients uptake and/or translocation in case of "Nabali" under field conditions, in accord to what Ferreira [19] had suggested that soil temperature affect olive tree ability to absorb nutrients.

"Manzanillo" and "Nabali Mohassan" had the best increment in shoot length (Table 6), which might indicate the response of the genotype under such conditions, these results are in agreement with those reported by Eryüce and Püskülcü [10] and Jordão *et al.* [9], who found that different olive cultivars showed different growth rates although they received the same fertilizer type and rate. Shoot length, shoot and root dry weight was significantly the least for "Nabali" (Table 6). This confirmed that "Nabali" is a slow growing cultivar, while "Manzanillo" and "Nabali Mohassan" were the faster growing cultivars. This indicates that the growth rate of various olive cultivars would respond differently even if they received the same levels of fertilizer.

Fertilizer effect: Result indicates that all fertilizer treatments did not show any significant differences in leaf NPK over the control under field condition (Table 5). However, trees received 48 g NPK had the highest N content among the treated trees, but they were on the same level of significant with the control and the rest of the treatments. In addition, leaf N content was more compare to that of greenhouse experiment. This result agrees with those obtained by Jordão *et al.* [14], who justified such increase to the higher N-reductase and other N metabolism enzymes activity and the environmental condition might affect particular nutrient uptake efficiency [2]. The increase in nitrogen content could also be referred to what Drossopoulos and Niavis [12] had concluded in their study that olive tree have lazy nitrogen metabolism and the dynamic nature of leaf nutrient composition that is influenced by plant age and nutrients interaction, which affects their uptake and distribution [4]. Moreover, young plants have vigorous growth, which makes nitrogen in demand and increase its absorption rate, in addition to it is importance as one of the two essential element of chlorophyll, which explain why "Nabali Mohassan" and "Manzanilo" had the highest shoot length compare to Nabali cultivar which is considered to be a slow growing cultivar (Table 6).

Phosphorus and potassium content under field condition was lower than that of the greenhouse condition. However, none of the treated trees had significant increase in leaf P and K content over the control (Table 5), these results are in agreement with those repoted by Eryüce and Püskülcü [10] on other olive cultivars, who had leaf phosphorus content within the reference range (0.8-3.0 mg g^{-1}), but the low P contents could be referred to the weather conditions that might be responsible for this variation since plant will consume energy for thermal regulation, leaves cooling. Therefore, nutrient contents in the leaves of the same tree may vary greatly from one season to another. Control trees had a better P contents compared with treated trees 1.36 mg g^{-1} (Table 5), this could be due to reduced uptake capacity, which is one factor that can influence P uptake by the root and this limitation may be greater for new roots that rapidly deplete P in the rhizosphere soil solution. Although, the 16 g/tree NPK and N showed higher P-content among the treated trees, which agree with Jordão *et al.* [14] results, who found that annual mean values of olive leaf phosphorus concentration did not significantly differ due to high fertilization dosage application.

Leaf K-content was within the optimum reference range (7.0-14.0 mg g^{-1}) as reported by Eryüce and Püskülcü [10] on other olive cultivars, in accord with Ferreira [11] suggestions that K assimilation starts with the beginning of the vegetative growth and accumulates in leaves since it is not heavily in demand at this period, but low K-contents could be related to the harsh weather conditions, since it had been suggested that K affect transpiration rate and participate in leaves cooling - air temperature ranges between 26 and 45°C [20], which increase K consumption by the plant, meanwhile, plants suffered from high temperatures and evaporation rate reduces potassium absorption [15]. Furthermore, plant age and production status may have considerable effect on its response to fertilization [11].

All NPK and N alone treatments with the exception of 48 NPK and N showed a significant increase in shoot length over the control (Table 6), same trend was also noticed under greehouse condition (Table 4), this could be attributed to the fact that olive's nutrient requirements are lower than that for many other fruit trees [1, 2] and therefore, young olive trees would benefit from low levels of NPK and N alone and additional fertilizers would not be significant. However, NPK are consider to be essential elements for plant growth and development as reported by Ferreira [11], who found that different NPK levels had significant influence on various growth parameters of olive trees such as shoot growth and extension. Shoot dry weight was significantly affected by all fertilizer treatment compare to control (Table 6). The 16 g NPK and 32 g N significantly gave the highest shoot and root dry weight, this probably due to nitrogen concentration that had been suggested by Neilsen and Lynch [18] to increase dry matter accumulation in roots and decreasing shoot: root ratio.

CONCLUSIONS

All cultivars seem to have better growth under greenhouse than field conditions. Irrespective of cultivars, fertilizer treatments significantly improved leaf N content under greenhouse conditions, while other elements did not positively affected under both conditions. This finding could be of great value to the nurserymen to grow their olive cuttings under control conditions for better marketing.

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