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Enhancement Vegetative Growth and Leaf Mineral Content of Manzanillo Olive Transplants Using Different Levels of Nitrogen and Molybdenum

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Abstract: The aim of this work was to study the effect of different levels of nitrogen and molybdenum on vegetative growth and mineral content of Manzanillo olive transplants. A pot experiment was carried out during two successive seasons of 2011 and 2012 under a glass house of the Faculty of Agriculture, Ain Shams University at Shoubra El-Kheima, Cairo, Egypt on Manzanillo olive transplants. The experiment included three nitrogen levels (N_1=25, N_2=50 and N_3=75g N/pot/year) and four levels of molybdenum (M_1=zero, M_2=10, M_3=20 and M_4=30 ppm Mo).Thus the experiment was laid out in factorial experiment in complete randomize design. Results showed that, N_2 level (50 g N/pot/year) gave the highest significant values in all vegetative growth characters. On the other hand, it was gradually increased in vegetative growth characters by increasing molybdenum level up to 20 ppm or 30 ppm. The combination between nitrogen and molybdenum levels, the best treatments were (N_2 x M_3) and (N_2 x M_4) which gave the highest values of most vegetative growth characters. Regarding leaf nutrient content, results pointed out that, level N $_2$ gave the highest values of N, P, K and Fe content. With respect to molybdenum levels, in most cases levels M_3 or M_4 (20 or 30 ppm Mo) gave the highest values especially for N, P, K, Fe and Mo. Regarding the interaction it could be concluded that, combining nitrogen with molybdenum increased macro-and micronutrients content of Manzanillo olive transplants.

Key words: Leaf mineral content · Molybdenum · Nitrogen · Olive transplants · Vegetative growth

INTRODUCTION

Olive (*Olea europaea* L.) is one of the oldest agricultural tree crops of remarkable cultural and economic importance in the Mediterranean Sea Basin also it represents a widely distributed fruit tree in the world [1]. Manzanillo is the most important commercial variety in the world [2]. Manzanillo is early ripening cultivar, well for table olives and for oil production and a heavy bearer. It is considered by many to be the best dual purpose variety available [3]. The growth rate of olive transplants is slow and it requires long time for growing to reach a suitable size, shorting this time would benefit by reducing various production in pots and their costs. Nitrogen is a macronutrient required in large quantity by plants and is absolutely essential to optimize crop yield. It is typically the primary limiting nutrient in both agroecosystems and natural ecosystems. Plants absorb nitrogen from soils as nitrate or ammonium ions. Farmers compensate for the inability of soils to provide sufficient nitrogen by applying nitrogen fertilizer, most commonly in the form of ammonia [4]. It has been known that, molybdenum is an essential micronutrient for plants, animals and microorganisms. Molybdenum occurs in more than 40 enzymes catalyzing diverse redox reactions, however, only four of them have been found in plant which, (1) Nitrate reductase catalyses the key step in inorganic nitrogen assimilation, (2) aldehyde oxidase have been shown to catalyse the last step in the biosynthesis of the phytohormone abscisic acid, (3) xanthine dehydrogenase is involved in purine catabolism and stress reactions and (4) sulphite oxidase is probably involved in detoxifying excess sulphite [5]. Molybdenum is directly related to metabolic function of nitrogen in the plant through nitrate reductase enzyme that reduces the nitrate to nitrite and this first step of incorporation of nitrogen to proteins. Mo-enzymes participate in essential redox reaction in the global C-, N- and S- cycles [6, 7]. The role of molybdenum

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in plants is discussed, focusing on its current constraints in some agricultural situations and where increased molybdenum nutrition may aid in agricultural plant development and yields [8].

Thus, the main goal of this research is to study the effect of different levels of nitrogen and molybdenum either alone or combined on Manzanillo olive transplants growth and their leaf mineral content.

MATERIALS AND METHODS

A pot experiment was carried out during two successive seasons of 2011and 2012 under a glass house in the Faculty of Agriculture, Ain Shams University at Shoubra El-Kheima, Cairo, Egypt. In the last week of February, in each season, one-year-old Manzanillo olives transplant (*Olea europaea* L.) were transplanted in 35 cm diameter pots (one transplant/ pot) in a mixture of sand and peat moss 3:1 (v/v). Transplants were almost uniform in length, growth and free diseases. Superphosphate (15.5% P_2O_5) and potassium sulphate (48% K_2O) were applied as sources of P and K added to the soil at the rate of 10 g/pot/year. The study was involved three levels of mineral nitrogen and four levels of molybdenum. Ammonium nitrate (33%N) was used as nitrogen fertilizer. Nitrogen treatments included three levels of nitrogen namely (N_1 = 25, N_2 =50 and N_3 =75 g actual N/pot/year). Ammonium nitrate levels were dissolved in irrigated water divided into 60 equal weekly doses through growing seasons (two doses/week) started from March to October. It should be pointed out that leaching had been carried out every two weeks by a rate of 1 liter of tap water per pot. Ammonium molybdate was applied twice by one liter per transplant (at the second week of March and July) as a source of different molybdenum concentrations: (M_1) = 0, (M_2) = 10, (M_3) = 20 and (M_4) = 30 ppm Mo. The experiment was laid out in factorial experiment in complete randomize design with five replicates each replicate was represented by one plant. The following characteristics were studied:

Growth Measurements: At the end of each season some growth characteristics were measured for stem diameter at 5cm above the ground surface, stem height and total number of leaves. Four fully expanded leaves from the middle of shoots 5-7th leaves from plant top were collected to measure the leaf area by a LI – COR –Portable area meter, Model L1–300. Area was expressed as cm^2. The same leaf samples were used to determine total chlorophyll content by using a SPAD – 502 MINOLTA chlorophyll meter. At the end of each season (first week of November) all plants were taken out carefully and separated into three parts (roots, stem and leaves) then oven dried at 60-70°C until a constant weight and the dry weight of each part was determined. Thereafter, the dry weight of whole plant was calculated.

Chemical Analyses: At the end of each season, dried green leaf samples were ground by means of an electric mill. Ground samples were digested according to the method of Jackson [9] and the digested solutions were used to determine nitrogen, phosphorus and potassium, iron, zinc, manganese and molybdenum [10].

Statistical Analysis: Data obtained in the two seasons were statistically analyzed by using the analysis of variance [11]. Means were differentiated by using Duncan's multiple range tests at 5% level of probability [12].

RESULTS AND DISCUSSION

Effect of Nitrogen and Molybdenum Levels on Some Vegetative Growth Parameters: Results in Table 1 show the effect of different nitrogen, molybdenum levels and their interaction on stem diameter, stem height and leaves number of Manzanillo olive transplants during 2011 and 2012 seasons. Data indicated that, fertilizing with the medium level of nitrogen (50g N/pot/year) gave the highest significant values of stem diameter. In the both seasons M_1 level (0 ppm Mo) gave the least significant value. Regarding the effect of other molybdenum levels, it is obvious that stem diameter was increased gradually by increasing Mo concentration up to M_4 which gave the highest values. On the other hand, the difference between these treatments (10, 20 and 30 ppm Mo) in most cases was lacked significance. Combining nitrogen and molybdenum in the two seasons had a significant effect on stem diameter. Therefore, it is observed that any given rate of molybdenum level (10, 20 and 30 ppm Mo) under the second level of nitrogen gave the highest significant values of stem diameter especially in the first season.

Regarding stem height the data in Table 1 showed that, the medium level N_2 gave the highest significant value for stem height. However, the high level N_3 gave lower values than those of level N_1 during the two growing season without any significant difference between them. In both seasons, M_1 level (0 ppm Mo) gave the least significant value. Regarding the effect of other molybdenum levels it is apparent that stem height was

Table 1: Effect of nitrogen and molybdenum levels on some vegetative growth parameters of Manzanillo olive transplants during 2011 and 2012 seasons

Molybdenum (ppm)	Stem diameter (mm) 25 (N_1)	50 (N_2)	75 (N_3)	Mean	Stem height (cm) 25 (N_1)	50 (N_2)	75 (N_3)	Mean	Leaves number/plant 25 (N_1)	50 (N_2)	75 (N_3)	Mean
					2011 season							
0 (M_1)	6.39c	7.19bc	6.71c	6.76B	81. 7e	86.7e	83.3e	83.9B	192.3gh	281.7cd	185.0h	219.7C
10 (M_2)	7.22bc	7.53a-c	7.16bc	7.30AB	100.3a-c	98.0a-d	90.0c-e	96.1A	196.3f-h	325.0bc	250.0d-g	257.1B
20 (M_3)	7.44bc	8.25ab	6.97bc	7.55A	88.0de	101.0ab	102.7a	97.2A	269.0c-e	415.0a	253.3d-f	312.4A
30 (M_4)	7.45bc	8.82a	6.57c	7.61A	89.3de	107.7a	90.7b-e	95.9A	292.3cd	361.7ab	208.7e-h	287.6AB
Mean	7.13B	7.95A	6.85B	--	89.8B	98.3A	91.7B	--	237.5B	345.8A	224.3B	--
					2012 season							
0 (M_1)	5.68e	6.93b-d	6.73b-d	6.45C	77.3d	80.3cd	82.0cd	79.9C	181.7g	253.3cd	192.3fg	209.1C
10 (M_2)	6.57cd	7.02bc	7.12bc	6.91B	84.7cd	94.3ab	86.7bc	89.0B	183.3g	316.7b	238.3cd	246.1B
20 (M_3)	7.24b	7.91a	6.44d	7.20AB	84.3cd	102.0a	94.7ab	93.7A	228.3de	363.3a	224.7d-f	272.1A
30 (M_4)	7.28b	8.16a	6.79b-d	7.41A	94.0ab	102.7a	85.3cd	94.0A	271.3c	340.0ab	198.3e-g	269.9A
Mean	6.69B	7.50A	6.77B	--	85.1B	94.8A	87.2B	--	216.2B	318.3A	213.4B	--

Nitrogen treatments (g N / pot)

In each season, means of each of nitrogen and molybdenum levels or their interactions having the same letters are not significantly different at 5% level

Table 2: Effect of nitrogen and molybdenum levels on leaf area and total chlorophyll (SPAD values) of Manzanillo olive transplants during 2011 and 2012 seasons

Molybdenum (ppm)	Leaf area (cm^2) 25 (N_1)	50 (N_2)	75 (N_3)	Mean	Chlorophyll (SPAD) 25 (N_1)	50 (N_2)	75 (N_3)	Mean
				2011 season				
0 (M_1)	3.19c	3.71bc	4.35ab	3.75B	76.7bc	79.0bc	76.0c	77.2B
10 (M_2)	3.78bc	4.24ab	3.99a-c	4.00AB	81.1a-c	83.9ab	82.1a-c	82.4A
20 (M_3)	4.26ab	4.29ab	3.67bc	4.07AB	81.8a-c	82.0a-c	81.3a-c	81.7A
30 (M_4)	4.91a	4.15ab	4.07a-c	4.38A	82.8a-c	87.3a	82.4a-c	84.2A
Mean	4.04A	4.10A	4.02A	--	80.6A	83.0A	80.5A	--
				2012 season				
0 (M_1)	2.99e	3.71b-d	4.01a-d	3.57B	75.6c	78.6a-c	78.2a-c	77.4B
10 (M_2)	3.43de	4.19ab	3.88a-d	3.83AB	76.0bc	81.3a	79.8a-c	79.0AB
20 (M_3)	3.76a-d	4.21ab	3.56d	3.84AB	80.2a-c	81.9a	81.7a	81.3A
30 (M_4)	4.35a	4.18a-c	3.57cd	4.03A	81.0ab	81.3a	81.0ab	81.1A
Mean	3.63B	4.07A	3.76B	--	78.2B	80.8A	80.2AB	--

Nitrogen treatments (g N/pot)

In each season, means of each of nitrogen and molybdenum levels or their interactions having the same letters are not significantly different at 5% level.

increased significantly by increasing molybdenum concentration up to M_3 which gave the highest values. Results also revealed that the interaction was significant in the 1st and 2nd seasons. The first level of molybdenum (0 ppm Mo) under any nitrogen level gave the lowest significant values of stem height in both the two seasons. On the other hand, it is observed that any given rate of molybdenum (10, 20 and 30 ppm Mo) under the second level of nitrogen gave the highest values of stem height.

Number of leaves was significantly affected with nitrogen, molybdenum levels and their interaction in the 1st and 2nd seasons. With respect to the nitrogen levels, it was observed that the highest values were obtained by level N_2. Whereas, the high nitrogen level gave the least value of leaves number. On the other hand, number of leaves was significantly increased by increasing molybdenum level up to 20 ppm. More increase in Mo level (30 ppm) did not differ significantly than M_3 level. Regarding the interaction untreated plant with molybdenum under any nitrogen level almost gave the lowest significant values of leaves number. When combining different rates of nitrogen and molybdenum, number of leaves was affected significantly. In the two season the highest significant values were obtained by treatments (N_2 x M_3) and (N_2 x M_4).

Effect of Nitrogen and Molybdenum Levels on Leaf Area and Chlorophyll Content: Results in Table 2 show the effect of different nitrogen, molybdenum levels and their interaction on leaf area and total chlorophyll content of Manzanillo olive transplants during 2011 and 2012 seasons. Leaf area was affected significantly by nitrogen

Table 3: Effect of nitrogen and molybdenum levels on dry weight of different parts and whole plant of Manzanillo olive transplants during 2011 and 2012 seasons

	Nitrogen treatments (g N/pot)															
	Leaves dry weight (g)				Stem dry weight (g)				Roots dry weight (g)				Whole plant dry weight (g)			
Molybdenum (ppm)	25 (N_1)	50 ((N_2)	75(N_3)	Mean	25 (N_1)	50(N_2)	75 (N_3)	Mean	25 (N_1)	50(N_2)	75(N_3)	Mean	25(N_1)	50(N_2)	75(N_3)	Mean
	2011 season															
0 (M_1)	5.97d	10.40b	7.56cd	7.98C	8.17e	11.7cd	10.48de	10.14B	3.30ab	3.16bc	2.96bc	3.14A	17.43g	25.23cd	21.01f	21.26B
10 (M_2)	6.90d	14.36a	10.58b	10.61B	10.78d	14.57b	13.97bc	13.10A	3.34ab	3.56ab	2.92b	3.27A	21.02f	32.48b	27.47c	26.99A
20 (M_3)	10.51b	15.14a	9.92b	11.86A	10.82d	18.00a	11.12d	13.22A	3.41ab	3.50ab	2.56c	3.16A	24.8c-e	36.65a	23.2d-f	28.33A
30 (M_4)	11.05b	14.88a	8.98bc	11.6AB	10.92d	18.33a	10.16de	13.14A	3.41ab	3.90a	2.58c	3.29A	25.4cd	37.11a	21.72ef	28.07A
Mean	8.61B	13.70A	9.26B	--	10.17C	15.67A	11.43B	--	3.37A	3.53A	2.76B	--	22.15B	32.89A	23.45B	--
	2012 season															
0 (M_1)	6.08g	9.49de	8.29f	7.99C	8.52e	10.65cd	12.36bc	10.51B	3.80a	3.33a-d	3.04a-d	3.39A	18.40e	23.47c	23.80c	21.89C
10 (M_2)	6.58g	13.80a	10.28cd	10.22B	8.71e	13.44ab	12.52ab	11.56A	3.17a-d	3.53a-c	3.00b-d	3.23A	18.46e	30.78a	25.80b	25.01B
20 (M_3)	8.17f	14.07a	8.57ef	10.27AB	9.56de	13.49ab	10.18de	11.07B	3.25a-d	3.65ab	2.76d	3.22A	20.98d	31.20a	21.51d	24.56B
30 (M_4)	10.55c	12.05b	9.80cd	10.80A	11.94bc	14.21a	10.00de	12.05A	3.51a-d	3.36a-d	2.77cd	3.21A	26.00b	29.62a	22.57cd	26.06A
Mean	7.85C	12.35A	9.26B	--	9.68C	12.95A	11.26B	--	3.43A	3.47A	2.89B	--	20.96C	28.77A	23.42B	--

In each season, means of each of nitrogen and molybdenum levels or their interactions having the same letters are not significantly different at 5% level.

level in the second season only. Results indicated that, the medium level N_2 gave the highest significant value for leaf area. Regarding the effect of molybdenum levels, in both seasons, the least values were obtained by the untreated plants (0 ppm Mo). However, other molybdenum levels gave more or less similar values from the statistical stand point. The interaction was significant in the two seasons. Generally, in both seasons, [treatments (N_1 x M_1) and (N_1 x M_2)] decreased leaf area significantly. Other combinations created more stimulative effect on leaf area but in most cases without significant differences between them.

Total chlorophyll content was affected significantly by levels of nitrogen in the second season only. Level N_2 (50 g N/pot/year) gave the highest value for total chlorophyll content. On the other hand, in the two seasons, level M_1 (0 ppm Mo) gave the least significant values of chlorophyll content. Other molybdenum levels gave more or less similar values which were similar from the statistical stand point. Results revealed that, different nitrogen and molybdenum combinations affected leaf chlorophyll content significantly. In the first season, fertilization with nitrogen alone [treatments (N_1 x M_1), (N_2 x M_1) and (N_3 x M_1)] decreased total chlorophyll content. Nevertheless, other combination gave more or less similar values with the statistical stand point.

From the foregoing results, it could be concluded that level N_2 (50 g N/pot/year) gave the highest significant values in all vegetative growth characters. On the contrary, high nitrogen level N_3 (75 g N/pot/year) gave the least values of most vegetative growth characters. It could be explain away by the high level of nitrogen may be caused salinity effect. This result is in agreement with those obtained by Tabatabaei [13], who pointed out that, the plants growth were improved at 200 mg l^{-1} N concentration in cvs Manzanillo and Zard, but it was reduced when the N concentration increased up to 300 mg l^{-1} in the nutrient solution. It can be concluded that increasing N concentration up to 200 mg l^{-1} in salt-sensitive cultivars to salinity is favorite in counteracting the adverse effects of salinity but the further increase of N concentration (300 mg l^{-1}) may be ineffective or even harmful for the olive trees growth. Otherwise, Keller *et al*. [14] showed an increase in grape leaf chlorophyll content as a result of the N applications. The degradation of chlorophyll was delayed as a result of N application as well as a delay in leaf senescence. Whereas, Aly [15] found that all treatments of soil nutrients N, P, K, Mg and EM increased olive leaf chlorophyll "A" and "carotene" contents. On the other hand, in the wine grapevine Vitis vinifera 'Merlot', poor growth during establishment and variable yields in mature plants grown in many South Australian vineyards is positively correlated with reduced petiolar molybdenum levels [16].

Effect of Nitrogen and Molybdenum Levels on Dry Weight of Different Parts of Transplant: Results in Table 3 show the effect of different nitrogen, molybdenum levels and their interaction on dry weight of different parts of Manzanillo olive transplants in 2011 and 2012 seasons. Dry weight of total leaves was affected significantly by levels of nitrogen, molybdenum and their interaction during the two seasons. Level N_2 (50 g N/pot/year) gave the highest significant value of dry weight of total leaves when compared with any other level in the two seasons. On the contrary, increasing nitrogen rate up to 75 g N/pot gave more or less similar values as those of level N_1 (25g N/pot). Regarding the effect of molybdenum levels. In both seasons, level M_3 (20 ppm) and M_4 (30 ppm) gave the highest significant values of leaves dry weight

Table 4: Effect of nitrogen and molybdenum levels on N, P and K content in leaves of Manzanillo olive transplants during 2011 and 2012 seasons

Molybdenum (ppm)	Nitrogen treatments (g N / pot) N% 25 (N_1)	N% 50(N_2)	N% 75(N_3)	N% Mean	P % 25(N_1)	P % 50(N_2)	P % 75(N_3)	P % Mean	K% 25(N_1)	K% 50(N_2)	K% 75(N_3)	K% Mean
						2011 season						
0 (M_1)	1.46c	1.57bc	1.65a-c	1.56C	0.169i	0.175h	0.197d	0.181C	0.926cd	0.985cd	0.913d	0.958B
10 (M_2)	1.47c	1.72ab	1.69ab	1.62BC	0.158j	0.181g	0.190f	0.177D	0.905d	1.13a	0.923d	0.986AB
20M_3)	1.65a-c	1.72ab	1.70ab	1.69AB	0.192e	0.213a	0.198d	0.201A	0.984cd	1.13a	0.907d	1.01A
30 (M_4)	1.69ab	1.85a	1.74ab	1.76A	0.206b	0.199c	0.175h	0.194B	1.08ab	1.04bc	0.921d	1.02A
Mean	1.57B	1.71A	1.70A	--	0.182C	0.192A	0.190B	--	0.987B	1.07A	0.916C	--
						2012 season						
0 (M_1)	1.40c	1.78b	2.00a	1.73A	0.145a	0.172a	0.170a	0.162A	0.920d	1.09ab	0.968b-d	0.993B
10 (M_2)	1.44c	1.85ab	1.97a	1.75A	0.153a	0.177a	0.165a	0.165A	0.960b-d	0.993b-d	0.937cd	0.963B
20M_3)	1.49c	1.99a	1.95a	1.81A	0.156a	0.197a	0.163a	0.172A	1.11ab	1.15a	0.968b-d	1.07A
30M_4)	1.48c	2.01a	1.95a	1.82A	0.186a	0.199a	0.170a	0.185A	1.07a-c	1.10ab	0.923d	1.03AB
Mean	1.45B	1.91A	1.97A	--	0.160A	0.186A	0.167A	--	1.02B	1.08A	0.949C	--

In each season, means of each of nitrogen and molybdenum levels or their interactions having the same letters are not significantly different at 5% level.

followed in a decreasing order by level M_2 (10 ppm) and level M_1 which gave the least significant value. With respect to the interaction, when combined the second level of nitrogen with (M_2, M_3 and M_4) molybdenum level gave the highest significant values of leaves dry weight. Therefore, it seems that treatment (N_2 x M_2) and (N_2 x M_3) gave the highest values of leaves dry weight in the two seasons.

Regarding stem dry weight in both seasons, the second level of nitrogen (N_2) gave the highest significant value of stem dry weight when compared with other levels. On the other hand, stem dry weight was affected significantly by the levels of molybdenum in the two seasons. Whereas, untreated plant gave the least significant values. Other treatments gave more or less similar values with the same statically stand point expect (M_3) level in the second season. The interaction was significant in the two seasons. Generally, the highest values of stem dry weight were obtained when combined the second level of nitrogen with (M_2, M_3 and M_4) molybdenum level. Therefore, it seems that treatment (N_2 x M_3) and (N_2 x M_4) gave the highest values of leaves dry weight in the two seasons.

Regarding root dry weight, nitrogen levels (N_1 and N_2) gave the highest significant values of roots dry weight in the 1st and 2nd seasons. On the contrary, increasing nitrogen rate up to (75 g N/pot) gave the least significant values. Dry weight of roots was affected insignificantly by molybdenum levels. The interaction was significant in the two seasons. Nevertheless, when combined the first or the second level of nitrogen with any molybdenum level gave more or less similar values which significantly higher than other combinations. Consequently, it seems that the high level of molybdenum uncreated pronounced effect on root dry weight.

Dry weight of whole plant was affected significantly by levels of nitrogen during the1st and 2nd seasons. Level N_2 (50 g N/pot/year) gave the highest significant value of plant dry weight when compared with any other levels. Generally, in the two seasons, all molybdenum levels increased plant dry weight significantly when compared with that of level M_1 (0 ppm). However the trend was clearer in the second season than the first one, whereas plant dry weight was gradually increased by increasing Mo up to 20 ppm and 30 ppm levels which gave the highest values in the 1st and 2nd seasons, respectively. Regarding the combination between nitrogen and molybdenum levels in the two seasons, almost the highest values were obtained by treatments (N_2 x M_3) and (N_2 x M_4). In this respect, Dag *et al*. [17] reported that enhanced olive root development under low N concentrations resulted in higher root weight compared with the high N concentration. On the other hand, Togay *et al*. [18] found that, lentil root and shoot dry weights were significantly affected from Mo fertilization. While, the greatest root and shoot dry weights were obtained from 6 g/kg lentil seed Mo applications, the lowest values were obtained from control plots in both years.

Effect of Nitrogen and Molybdenum Levels on Leaf Macronutrients Content: Results in Table 4 show the effect of different nitrogen, molybdenum levels and their interaction on N, P and K content in leaves of Manzanillo olive transplants in 2011 and 2012 seasons. Results proved that in both seasons, nitrogen percentage was affected significantly by the levels of nitrogen. Level N_1 (25 g N/pot/year) gave the lowest significant value of leaf nitrogen content when compared with any other levels. On the contrary, level N_2 (50 g N/pot/year) gave more or less similar values as those of level N_3 (75 g N/pot/year) in the two seasons. Regarding molybdenum levels in the first season only, nitrogen content was affected significantly by molybdenum levels. Whereas, the highest significantly values of nitrogen content were obtained by M_3 and M_4 in the first season. With respect to combination between nitrogen and molybdenum levels, nitrogen content was decreased by the first level of nitrogen under any given of molybdenum levels especially in the second season. However, other combinations created more stimulative effect on leaf nitrogen content but without significant difference among them. The highest values were obtained by treatment (N_2 x M_4) in both seasons. From the results of the two seasons, it is clear that adding molybdenum irrespective to the application level combined with the second and third level of nitrogen increased leaf nitrogen content. However, the second level of nitrogen more suitable because it is more economic and keep the environment from pollution.

Phosphorus content was affected significantly by nitrogen, molybdenum levels and their interaction in the first season only. Regarding the effect of nitrogen levels, the highest significant values were obtained by level N_2. However, more increase in nitrogen level N_3 decreased phosphorus content significantly. On the other hand, phosphorus content was gradually increased by increasing molybdenum up to 20 ppm level which gave the highest value. In the second season, molybdenum levels gave more or less similar values which were similar from the statistical stand point. It is quite evident that in the two seasons, phosphorus content was gradually increased by increasing the level of molybdenum up to M_4 and M_3 under the first and second nitrogen level, respectively and the highest significantly value of phosphorus content was obtained by N_2 x M_3 treatment especially in the first season.

The values of potassium content in the 1st and 2nd seasons were significantly affected by nitrogen, molybdenum levels and their interaction. Consequently, there was a gradual increase in potassium content by increasing nitrogen level up to (50 g N/pot/year) but more increase reduced potassium content and the highest nitrogen level (75 g N/pot/year) gave the least potassium value. Generally, M_1 gave the least potassium values with other levels. However, other levels gave more or less similar values. Meanwhile, when combining nitrogen with molybdenum levels, high values were obtained almost when combining the first and second levels of nitrogen with the (M_3 and M_4 levels). The highest values were obtained by treatment (N_2 x M_3).

The previous results are in agreement with those obtained by Emtithal *et al*. [19], who stated that adding nitrogen and/or potassium increased leaf nitrogen content of Manzanillo olive trees. On the other hand, application of Mo led to an increased accumulation of K^+ ions up to two-fold compared to the respective Mo-untreated wheat plants. Mo enhanced absorption of a large amount of K^+ from the soil to the root (about two-fold as compared to the respective Mo-untreated plants). This could be linked to the higher accumulation of proteins and/or the increased absorbing zones as indicated by the increase in root fresh and dry weights [20]. Kaiser *et al*. [21] reported that, molybdenum deficiencies are primarily associated with poor nitrogen health particularly when nitrate is the predominant nitrogen form available for plant growth. Inability to synthesize MoCo will reduce the activity of the critical nitrogen-reducing and assimilatory enzymes including NR and XDH.

Effect of Nitrogen and Molybdenum Levels on Leaf Micronutrients Content: Results in Table 5 show the effect of different nitrogen, molybdenum levels and their interaction on Fe, Zn, Mn and Mo content in leaves of Manzanillo olive transplants in 2011 and 2012 seasons. Generally iron content varied from season to season. In the second season only, iron content was affected significantly by nitrogen levels. However, in the first season, level N_3 gave the higher values than other nitrogen levels. Contrary, in the second season, the highest significant iron value was obtained by N_1 and N_2 levels. Thus no clear trend could be detected. In the second season only, iron content was affected significantly by molybdenum levels and the highest level of Mo gave higher significant values than other levels. Results revealed that, the interaction was significant in the two seasons. In the second season only, the lowest significant values were obtained when combing the third level of nitrogen (75 g N/pot/year) with (0, 10 and 20 ppm Mo). Generally, the results of the1st and 2nd seasons clearly indicated that iron content was more or less similar for most treatments.

Zinc content was not affected significantly by nitrogen, molybdenum levels and their interaction in the two seasons. Molybdenum had no effect on zinc content in leaves of Manzanillo olive transplants. So, the results of both seasons clearly indicated that zinc content was more or less similar for most treatments.

Table 5: Effect of nitrogen and molybdenum levels on Fe, Zn, Mn and Mo content in leaves of Manzanillo olive transplants during 2011 and 2012 seasons

Molybdenum (ppm)	Fe (ppm)				Zn (ppm)				Mn (ppm)				Mo (ppm)			
	25 (N_1)	50 (N_2)	75 (N_3)	Mean	25 (N_1)	50 ((N_2)	75 (N_3)	Mean	25 (N_1)	50 (N_2)	75 N_3)	Mean	25 (N_1)	50 (N_2)	75 (N_3)	Mean
2011 season																
0 (M_1)	223a-c	160c	234a-c	206A	26a	26a	25a	25A	69a	111a	95a	91A	0.788b	0.788b	0.713b	0.763C
10 (M_2)	212a-c	274ab	279a	255A	20a	25a	27a	24A	83a	114a	80a	92A	0.938ab	0.938ab	0.800b	0.893BC
20 (M_3)	220a-c	167bc	223a-c	203A	23a	24a	27a	24A	88a	89a	86a	87A	0.963ab	0.875b	1.30a	1.05AB
30 (M_4)	215a-c	205a-c	246a-c	222A	29a	27a	27a	27A	108a	119a	75a	100A	1.09ab	1.06ab	1.31a	1.16A
Mean	217A	201A	246A	--	24A	25A	26A	--	87A	108A	84A	--	0.945A	0.915A	1.03A	--
2012 season																
0 (M_1)	190c	215a-c	206bc	203B	22a	23a	26a	23A	60cd	82a-d	95a	79A	0.800e	0.800e	0.925de	0.843D
10 (M_2)	221a-c	210a-c	206bc	212AB	28a	25a	25a	26A	59d	88a-c	94a	80A	0.825e	1.05cd	1.18bc	1.02C
20 (M_3)	233a-c	260a	190c	227AB	25a	23a	24a	24A	61cd	99a	91ab	83A	0.950e	1.20bc	1.48a	1.21B
30 (M_4)	253ab	243ab	210 a-c	235A	22a	22a	25a	23A	65b-d	104a	94a	87A	1.25b	1.43a	1.55a	1.41A
Mean	224.3AB	232.0A	203B	--	24A	23A	25A	--	61B	93A	93A	--	0.958C	1.12B	1.28A	--

In each season, means of each of nitrogen and molybdenum levels or their interactions having the same letters are not significantly different at 5% level.

Manganese content was affected significantly by nitrogen levels in the second season only. Levels N_2 and N_3 gave the highest significant value of manganese content followed in a decreasing order by those of levels N_1. Therefore, it seems that manganese content was gradually increased by increasing the level of nitrogen up to 50g/pot/year (level N_2).

Manganese content was affected insignificantly by the levels of molybdenum in 1st and 2 nd seasons. Therefore, molybdenum had no effect on manganese content in leaves of Manzanillo olive transplants. The interaction was significant in the first season only. Whereas, in the second season treatments under the low level of nitrogen gave lower significant values compared with other combinations. Generally molybdenum content varied from season to season. In the second season, molybdenum content was affected significantly by nitrogen levels. However, in both seasons, level N_3 gave the highest values of leaves molybdenum content compared with other levels.

Molybdenum content was affected significantly by the levels of molybdenum in the two seasons. The least significant values were obtained by level M_1 (0 ppm Mo). Meanwhile, molybdenum content increased gradually by increasing molybdenum level and the highest values were obtained by M_4 level (30 ppm) molybdenum. Results revealed that the interaction was significant in the 1st and 2nd seasons. In both seasons, it is observed that under any given level of nitrogen treatments, increasing the level of molybdenum up to 30 ppm increased leaf molybdenum content. Consequently, it could be concluded that, treatment (N_1 x M_4), (N_2 x M_4), (N_3 x M_3) and (N_3 x M_4) gave the highest values of molybdenum content. Optimum levels of leaf macro and micronutrients content in olive leaf sample (N = 1.5-2%, P = 0.1-0.3%, K= 0.8-1%, Fe = 90-124 ppm, Zn = 10-24 ppm and Mn = 20-36 ppm) [22].

Form the forgoing results it could be concluded, that nitrogen levels affected nutrient content considerably. Level N_2 (50 g N/plant/year) gave the highest values of N, P, K and Fe content. That is according with those reported by Cesco *et al.* [23], who suggested that 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. Other studies pointed out that, the maximum values of the leaf area and N content were recorded on the Anna apple trees fertilized with N through 50 % mineral + 50 % compost + EM + molybdenum. Supplying the trees with N through 25 % mineral + 75 % compost + EM + molybdenum gave the maximum values of P, K, Zn, Fe and Mn in the leaves [24]. Evaluate the effect of molybdenum under different levels of nitrogen on growth, yield quantity and quality of cowpea. The results indicated that, molybdenum addition gave the highest figures of all growth and yield parameters of cowpea compared with the control (100% N) followed by 75% N. Molybdenum significantly increased the content of N, P, K, Mn, Fe, Cu, Zn and Mo as well as chemical contents with all nitrogen percentages [25].

CONCLUSION

From the foregoing results, it could be concluded that level N_2 (50 g N/pot/year) gave the highest significant value in all vegetative growth characters. On the other hand, all molybdenum levels increased vegetative growth parameters when compared with molybdenum level M_1 (0 ppm). In most cases, it was gradually increased in vegetative growth characters by increasing molybdenum up to 20 ppm or 30 ppm levels. Regarding the combination between nitrogen and molybdenum levels in most cases, it is clear that vegetative growth of Manzanillo olive transplants was increased by medium level of mineral nitrogen under any given molybdenum level and the best treatments were (N_2 x M_3) and (N_2 x M_4) which gave the highest values of stem length, number of leaves and whole plant dry weight. Accordingly, it seems that combining nitrogen with molybdenum creates more favorable effect on vegetative growth of Manzanillo olive transplants than adding nitrogen alone. Regarding the effect of nitrogen and molybdenum levels on leaf nutrient content, results proved that nitrogen levels affected nutrient content considerably. Level N_2 (50 g N/plant/year) gave the highest values of N, P, K and Fe content. With respect to molybdenum levels, in most cases levels M_3 and M_4 (20 and 30 ppm Mo) gave the highest values than those of other levels especially for N, P, K, Fe and Mo. Depending upon the values of interaction between nitrogen and molybdenum levels, it could be concluded that, combining nitrogen with molybdenum creates slightly more appreciable effect on macro-and micronutrients content of Manzanillo olive transplants than adding nitrogen alone. Generally, different combinations gave more increase in leaf mineral content. Otherwise, Molybdenum (Mo), a constituent of nitrogenase (NA) and nitrate reductase (NR), is required for the assimilation of soil nitrates. The biochemical and biophysical properties of molybdenum (Mo)-containing nitrogenase from a variety of diazotrophic organisms especially those from *Azotobacter vinelandii* and *Klebsiella pneumonia* [26]. So, more research work should be carried out to evaluate the role of molybdenum especially with free nitrogen fixing bacteria on nitrogenase and nitrate reductase activity, growth, mineral content and yield of fruit trees under organic culture orchards.

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